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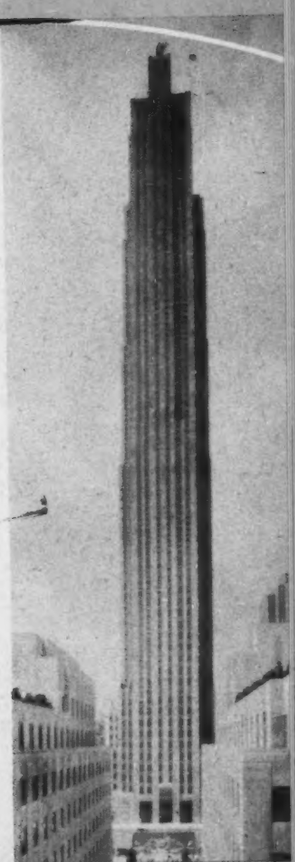

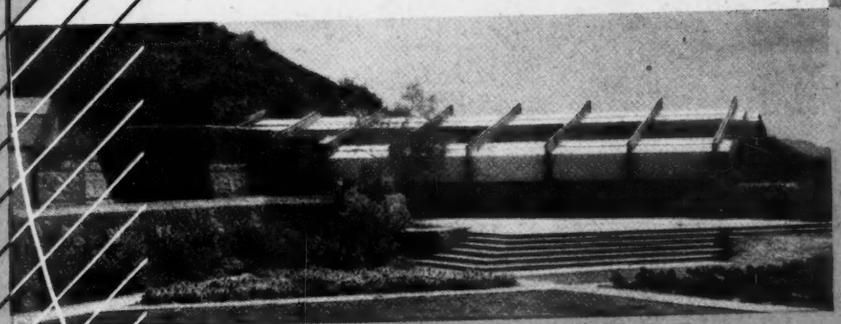

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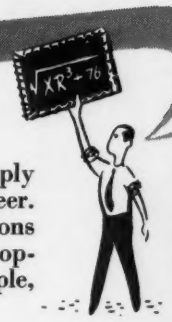

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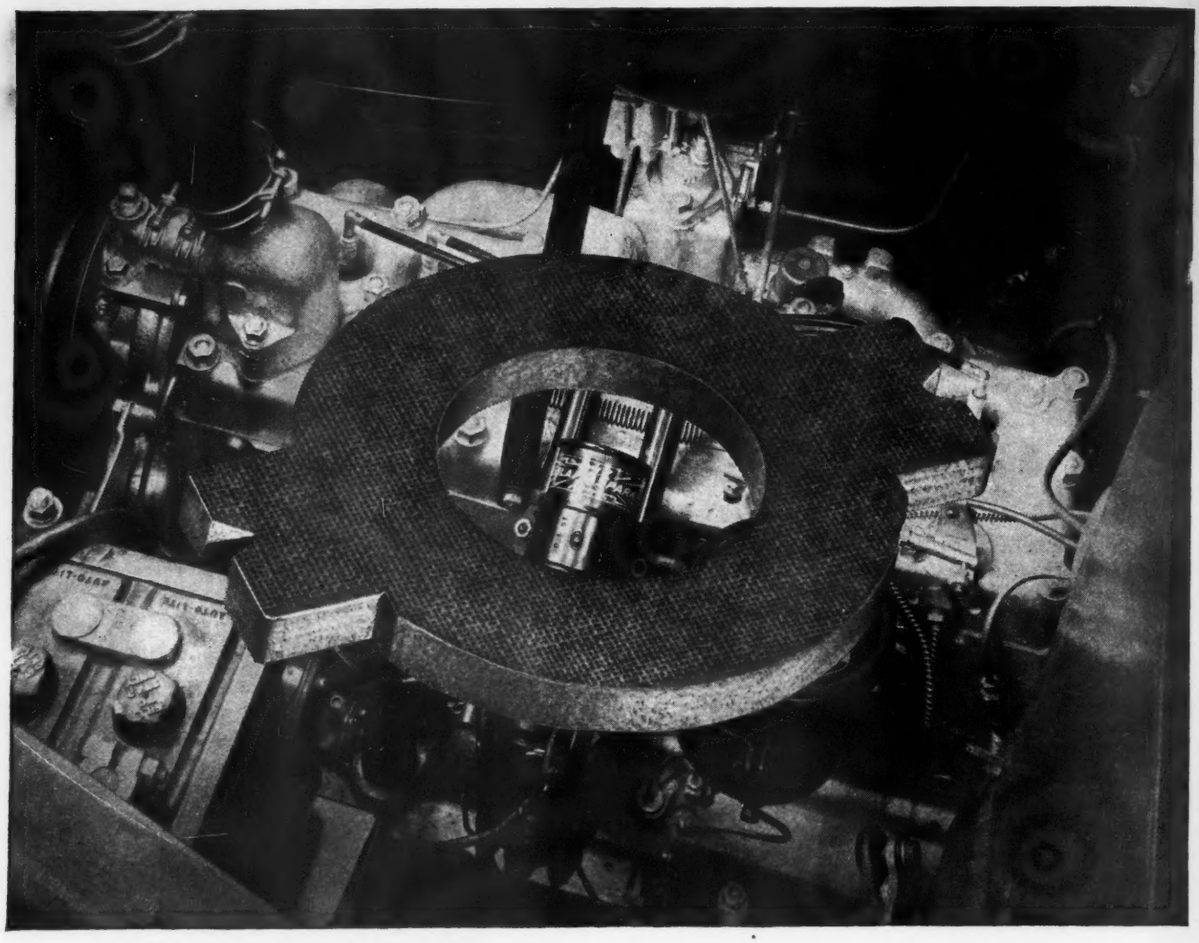
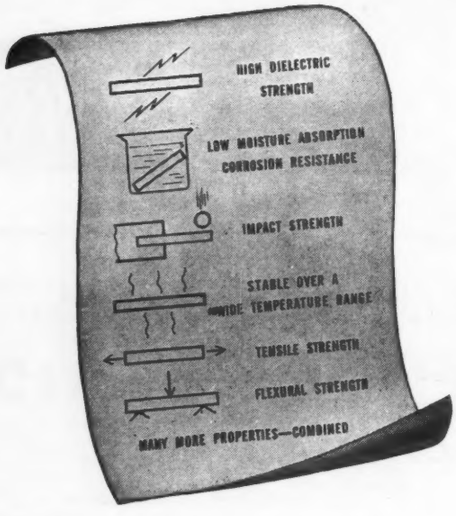
Plastics where plastics belong for resistance to wear and moisture



Synthane where Synthane belongs



HERE's Synthane (our type of laminated plastics) at work in the water pump of a popular car, where resistance to wear and moisture are important.

This seal washer is lapped to fit precisely, seals watertight without packing, resists—mile after mile—the inroads of engine cooling water. It's an appropriate job for moisture-resistant Synthane, a good example of using plastics where plastics belong. Synthane has many other unusual mechanical, electrical, physical and chemical properties. It is light (½ the weight of aluminum), dense, strong, resists heat, impact, corrosion, is a good electrical insulator, and easily machined. It is a practicable material for a limitless number of applications. Synthane Corporation (Key Address) Oaks, Pennsylvania.

SYNTHANE

SYNTHANE TECHNICAL PLASTICS • DESIGN • MATERIALS • FABRICATION • SHEETS • RODS • TUBES • FABRICATED PARTS • MOLDED-MACERATED • MOLDED LAMINATED

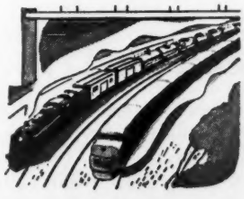
We're not so hot on POGO STICKS

Lots of people like to play jack rabbit. Still, as a way of going to work every morning, we don't see much of a future for Pogo Sticks. Not even *aluminum* Pogo Sticks.

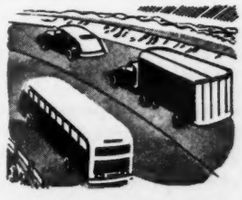
But mention any other means of locomotion or transportation and our aluminum "Imagineers" get a gleam in their eyes. After all, what is more logical than vehicles made of aluminum? Less weight to move. More payload.

We turned our imagination loose on that idea years ago . . . then engineered our thinking into trains, trucks, planes, ships. Alcoa's Development Division has a staff of "Imagineers" who think of nothing else but better ways to transport people, products, and materials by using aluminum. Actually, we have *four separate* staffs of transportation engineers, one each on railroads, highway vehicles, ships and aircraft.

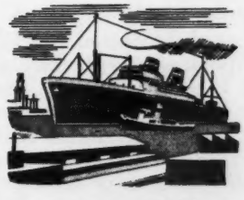
Whatever you do after college, you'll benefit from that. If you go into transportation, these Alcoa engineers will be working with you to cut costs, speed schedules, improve facilities. Or if you choose some field of production, they'll be helping to transport your materials and finished goods cheaper and faster. ALUMINUM COMPANY OF AMERICA, Gulf Building, Pittsburgh 19, Pennsylvania.



Passenger streamliners, refrigerator cars, hopper cars and tank cars built of Alcoa Aluminum are serving American railroads.



Alcoa Aluminum is finding more and more uses in buses, trucks and trailers. Yes, in passenger car manufacture, too.



Newest thing in shipbuilding is the aluminum superstructure, developed by Alcoa with marine architects and engineers.

Ever since Kitty Hawk, Alcoa has worked with the aircraft industry in developing better aluminum for better planes.

ALCOA FIRST IN ALUMINUM

Briefing the News . . .

Atomography . . .

WITH the aid of a special kind of photographic film with an emulsion much thicker than that of ordinary film, physicists C. F. Powell and G. P. S. Occhialini of the University of Bristol, England, have been able to take direct photographs of the explosions that take place in nuclear reactions. A radioactive substance, such as radium or thorium, is mixed into the emulsion of the film, where it disintegrates to form a variety of particles. These particles set up powerful electrostatic fields along their paths and cause part of the sensitive silver compound present in the film emulsion to be reduced to metallic silver. After developing, these paths appear as dark lines, easily visible under the microscope.

The same film was used to obtain photographs of the impact of cosmic rays on the emulsion; in some cases, as many as twenty paths could be seen originating from a single point where an atomic disintegration took place, thus indicating that the reaction involved the ejection of at least twenty energy carriers.

The new film used by the English scientists is more effective than ordinary photographic films for taking atomic pictures because the greater depth of the emulsion forms a three dimensional region in which a nuclear reaction could take place and be photographed. In conventional films, the emulsion is so thin that only particles traveling in the plane of the emulsion would appear on the photographic plate, thus giving a rather incomplete picture of what is transpiring in a nuclear reaction. In addition, the photographic films used for the atomic-reaction photographs have an unusually high concentration of sensitive silver salts, so that sufficient silver is reduced along the particle tracks to cause them to become visible after developing.

Smelling by Radar . . .

A new theory of the mechanism of smelling has been proposed by Professors Lloyd Beck and Walter Miles of Yale University. They believe that the nose acts like a miniature transmitter of infra-red rays, and that smell is based on the partial reflection of these waves back to the nose by molecules in the surroundings. Odorous substances, they hold, absorb certain frequencies in the infra-red spectrum, and the absence of these frequencies in the reflected radiation is detected by the nose and interpreted by the brain as a "smell."

The experimenters arrived at this unusual conclusion largely on the basis of experiments with insects. They found that roaches and bees, for example, are attracted to honey and other odoriferous substances even when they are completely enclosed, provided that the walls of the container are made of a material like potassium bromide which easily transmits infra-red radiation.

The investigators also believe that the new theory may well apply to man and the higher animals as well as to the lower orders on which the experiments were carried out. This does not mean that the entire process of smelling consists of the transmission and absorption of infra-red light, for there is an overwhelming amount of evidence available to show that the molecules of an odoriferous substance must be present near the nose for smelling to take place. Among them can be mentioned the fact that odors are carried by winds whereas infra-red radiation, like the whole electromagnetic spectrum, would be completely unaffected by air movements. Furthermore, it is well known that only materials with an appreciable vapor pressure have an odor; substances which are wholly non-volatile are also odorless. However, it is still possible that the final step in smelling, in the immediate vicinity of the olfactory nerve endings, might occur through this mechanism of infra-red absorption. As yet, the scientists have offered no direct proof for this hypothesis.

Phosphorylase . . .

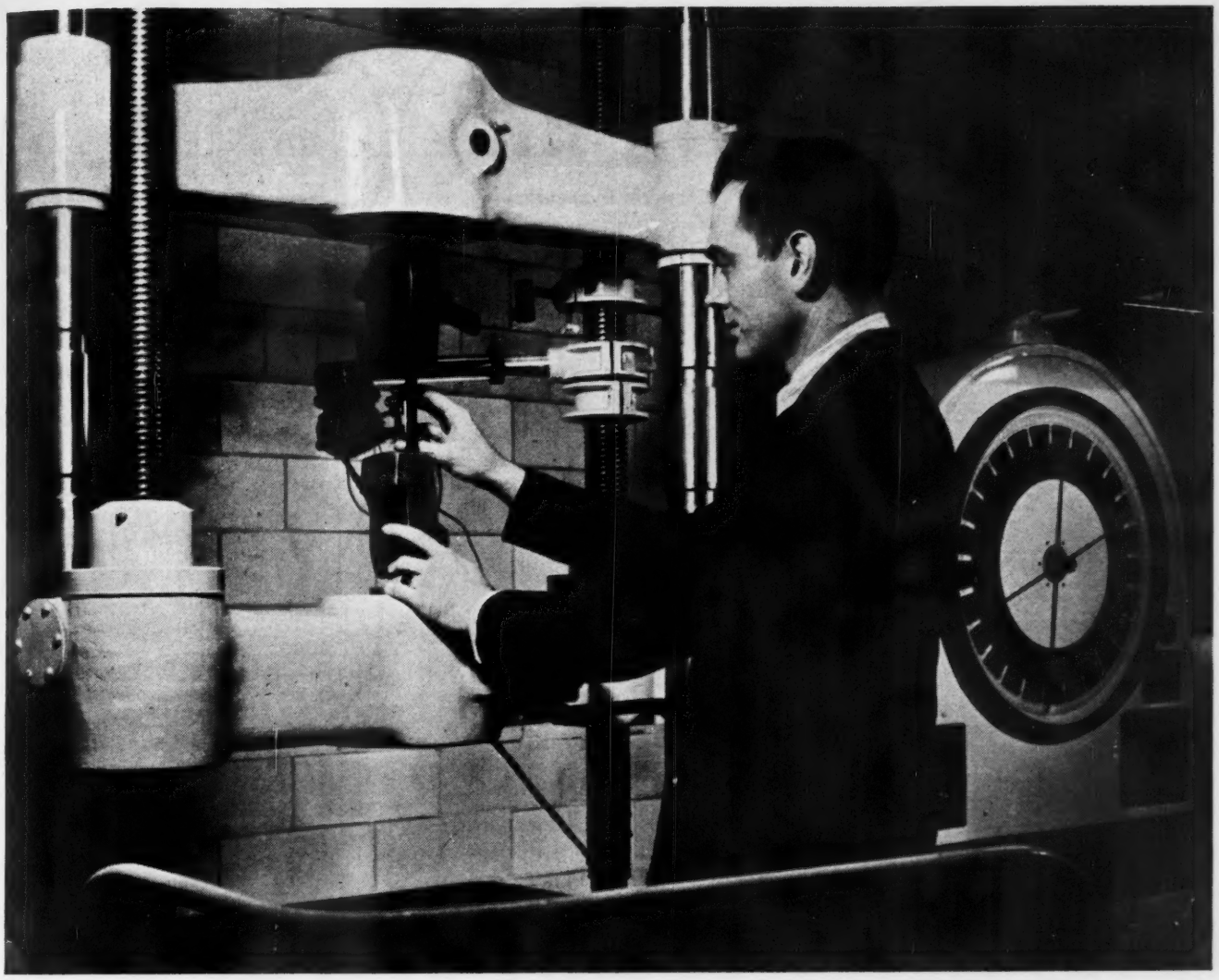
Last year, two American scientists, Dr. Carl Cori and his wife Dr. Gerty Cori, received half of the coveted Nobel prize in medicine for their remarkable work in discovering how the human body converts sugar into animal starch and vice versa. Working at the Washington University School of Medicine at St. Louis, Missouri, they even succeeded in synthesizing animal starch from a derivative of ordinary glucose or corn sugar, in a manner parallel to the body's own chemical process.

The secret lay in a new enzyme, or organic reaction-helper, that was found to cause molecules of the glucose derivative, known as glucose-1-phosphate, to combine with one another to form a molecule of glycogen, commonly known as "animal starch." It serves the same purpose in animals as ordinary starch does in plants, namely, as a storehouse for sugar. The enzyme, which was named phosphorylase by the two scientists, not only aids in the formation of glycogen from glucose, but also helps the glycogen to break down into glucose for use as a source of energy for the body's tissues. It was in this reaction that phosphorylase first came to the attention of the Doctors Cori. They found that glycogen extracted from animal muscle eventually broke down into glucose-1-phosphate, but that if the muscle fibers were washed briefly with water before being allowed to stand, the decomposition of the glycogen was stopped completely. Therefore, they decided that some chemical soluble in water was necessary for the decomposition of the glycogen into glucose-1-phosphate. They finally isolated the compound responsible for the decomposition of glycogen and called it phosphorylase. Subsequently, they found that phosphorylase caused the reverse reaction to take place, too; thus, phosphorylase was necessary for both the synthesis and decomposition of glycogen.

1000 M. P. H. Rocket Sled . . .

A rocket-propelled sled, with a record of 1019 miles per hour already to its credit, was the development of the Northrop Aircraft Company. The 1500-pound contraption was built to slide along a 2000-foot railroad track on magnesium shoes. In the first test, it covered the distance in less than two seconds, and then sped off the track and into the desert.

The company indicated that the rocket craft, which had attained a speed well above the speed of sound (750 m.p.h. sea level), at which ordinary aircraft are nearly battered to pieces by the turbulent pressure waves in the air, would be used to test aircraft wings and other parts at supersonic velocities.



Working in a Dow physical research laboratory, this young man is operating a machine to test plastic materials.

Plastics—a growing field for the young technician

Interest in the use of plastics grows apace. Products in great variety for the revived consumer's market show their influence —their special utilitarian value—their ready adaptability to ideas in design—their distinctive beauty.

Plastic materials are custom made in the laboratory for modern living. Dow chemists have developed many new plastics among which is Styron, a material that rose to a leading place during the war years. It is a remarkable combination of brilliant beauty and properties of a strictly utilitarian nature. Today, Styron is in demand for products that range from toys and costume jewelry to batteries and automobile parts. Many top-rate refrigerator makers use it in ice compartment doors, shelves and other parts.

Other Dow plastics are: Saran for colorful fabrics that can be cleaned with a damp cloth, non-rusting window screen or corrosion-resistant pipe and tubing; Saran Film and Ethocel Sheeting for better packaging; and Ethocel for durable molded products.

Development, testing and production of these plastic materials are carried on by technical men with special training. It is a great and growing field for young men who can turn their college training in this direction.

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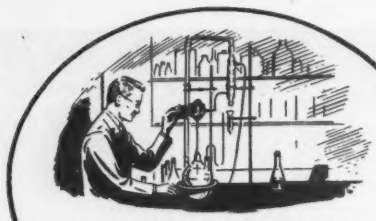
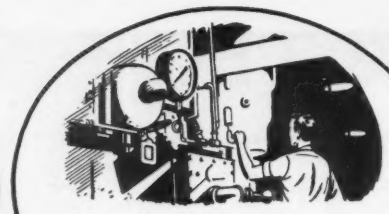
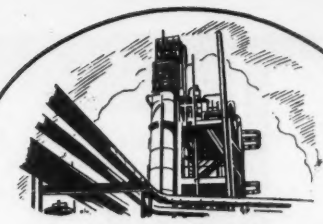


Basic Chemical Research—
Physical chemistry, organic chemistry and bio-chemistry.

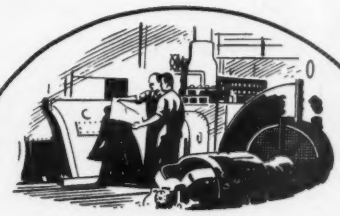


Chemical Engineering—
Product and process development through pilot plant and plant scale.



Equipment Engineering—
Design and development of processing equipment and automatic machinery.

Science Advances on Many Fronts at Procter & Gamble



Heat and Power Engineering—
Design and development of power plants, refrigeration, heating.

Factory Management—
Supervision of men, materials and machines in 29 plants.

Industrial Engineering—
Job and method studies, cost control development.

Personnel Administration—
Employment, training, health and safety.

Leadership . . .

Leadership in one form of science is based on teamwork in many.

That's why Procter & Gamble, long a leader in the chemical industry, also is making important advances in mechanical, electrical and industrial engineering.

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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By Charles Jordan

TITLE PAGE

This radio relay station on Bear Hill, near Waltham, Massachusetts, is typical of the seven relays A. T. & T. has built between Boston and New York

A. T. & T.

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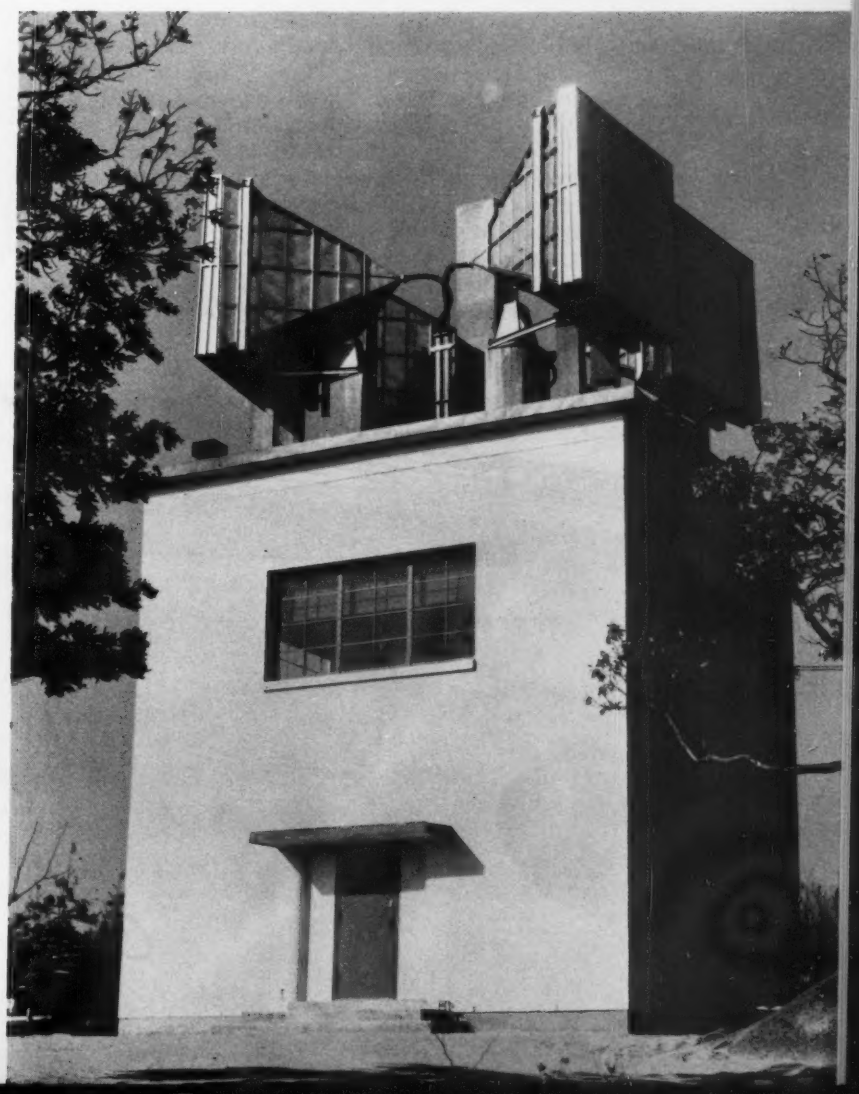
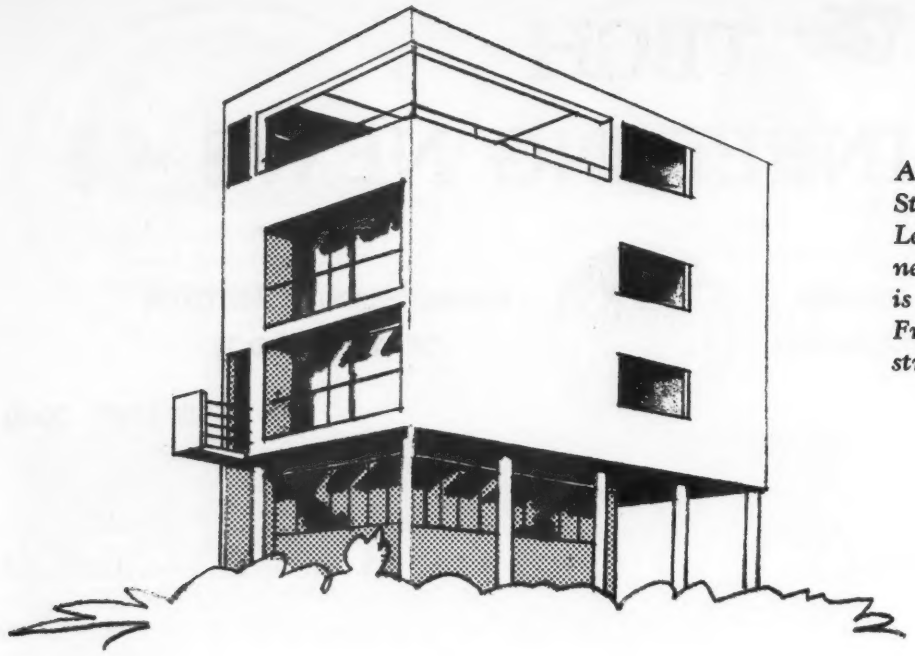
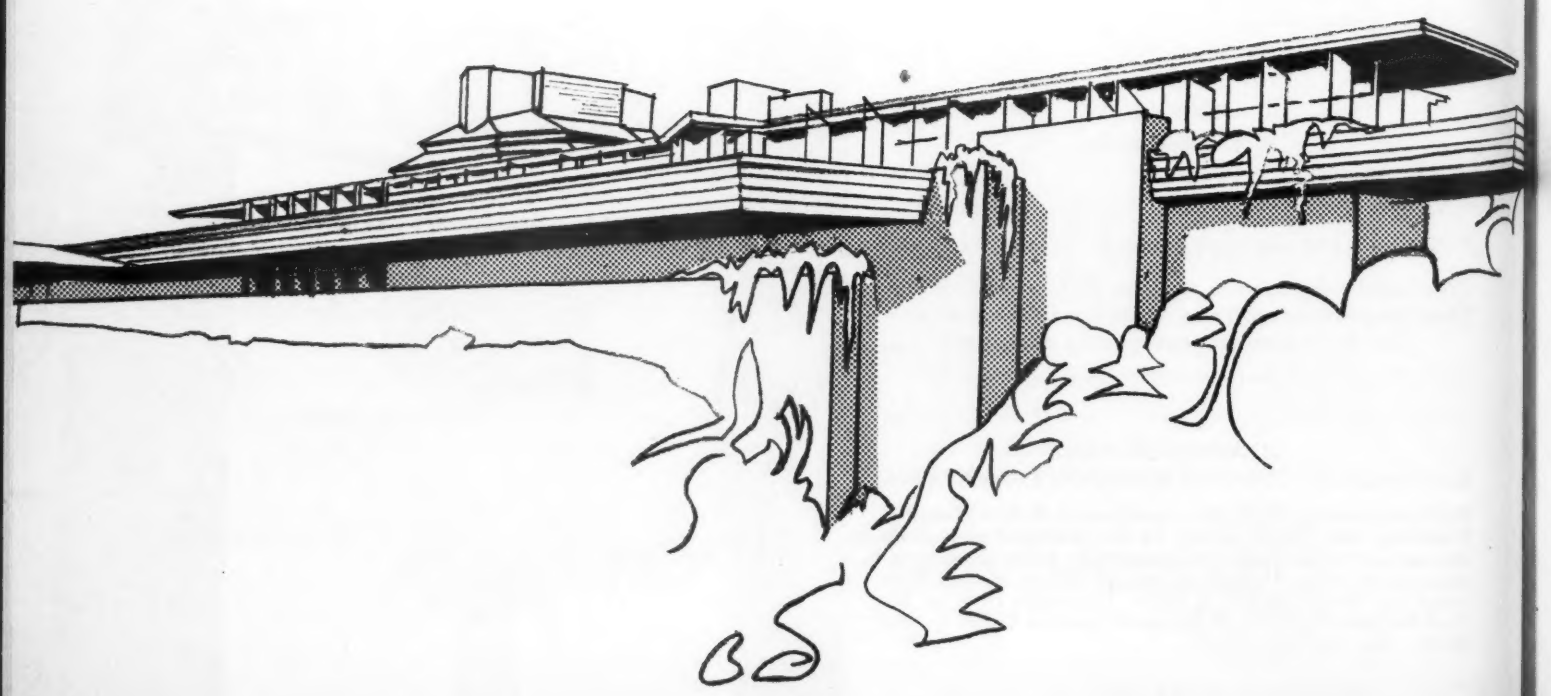




At the left is a sketch of a house in Stuttgart, Germany, designed by Le Corbusier. It features lightness of construction. While below is a sketch of the Johnson house. Frank Lloyd Wright as architect stressed closeness to the earth here

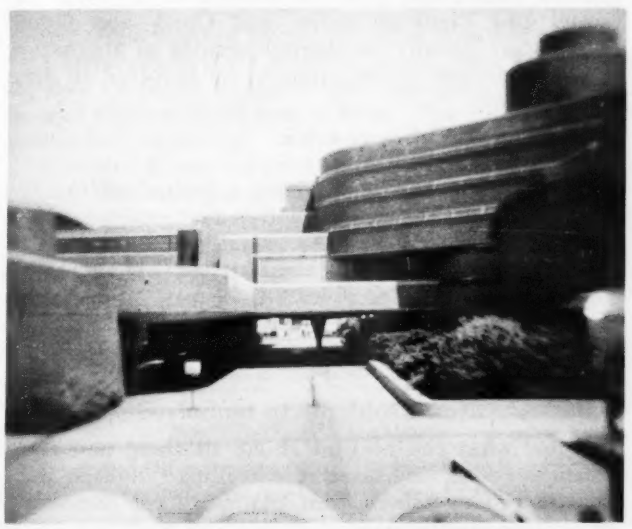


New-Found Forms

Modern architects, while solving engineering problems with latest techniques, are also expressing the character of the people they serve.

By RICHARD D. AHERN, '50

WHAT side of the fence are you on—do you like "modern" architecture or do you dislike it? Without hesitation you logically reply, "What *type* of modern architecture do you have in mind?" But had you been asked at the beginning of the Gothic period (when Gothic was "modern"), "Do you like 'modern' architecture?" you would have replied immediately either yes or no, for Gothic architecture was the manifestation of a single spirit — the expression of worshiping God above through structure. Our modern architecture, however, represents many different spirits.



Frank Lloyd Wright designed the Johnson Wax Company's office building in Racine, Wisconsin, for permanence

Greek architecture was an expression of Greek ideals; Roman architecture was an expression of Roman ideals; and Gothic, of late Medieval ideals.

It was at the beginning of the last century that "styles" began to become fads that would come and go within a few years, until the trend accelerated to a point where *any* style (as long as it was novel) was in good taste. This was eclecticism.

Now we have "modern" architecture, architecture that cannot be explained in terms of one great new movement. Again we have many "styles," but a new set of styles. Why do we have so many? What ideals does each express? Are they here to stay or are they merely passing fads? What do they have in common with great architecture? What are the fundamental differences between modern architecture and periods of the past? These are questions we must answer if we are to evaluate modern architecture.

Perhaps a brief inquiry into the history of the evolution of architecture would be helpful in making an analysis of the present situation.

The Evolution of Architecture

The Pharaohs of Egypt ruled their subjects with an iron hand. They needed an architecture that would express their complete domination over their subjects. They also faced a technical problem — how to span large spaces. The latter problem was solved by means of the post and beam, an invention of primitive man, but here the posts were developed into huge columns and the beams spanned tremendous spaces. The result was an awe-inspiring mass of monumentality that completely expressed the desired effect of dominance.

The Greeks had the same technical problem the Egyptians had, and also used the basic concept of post and beam. But the people of Greece were different from the Egyptians. Theirs was a race where the individual's rights were respected. Dignity and simplicity were elegantly expressed in their buildings. This is a case where two races used the same method of construction, but by means of placement and proportion achieved entirely different effects. Both were functional; both were beautiful.

Rome accepted the Greek heritage, but by means of the arch, the dome, the vault, and the use of concrete, transformed the "Glory that was Greece" into the "Grandeur that was Rome." The Romans gained a greater variety of composition and greater flexibility of plan than had the Greeks. However, they often used the building elements like toy blocks, arbitrarily placing them in illogical arrangements. Thus, improvements in architecture, like most advances toward civi-

The Shuckl Canning Company's office building in Sunnyvale, California, was designed by William Wilson Wurster, Dean of Architecture at M. I. T.

lization, bring greater complications and more opportunities for misapplication along with their virtues.

Builders of Gothic cathedrals wanted their structures to inspire the people. The logical solution was the emphasis of the vertical direction. No longer was there the post and beam; here was a pointed arch supported by lofty piers and sustained by buttresses. Greater heights were reached. The beauty of the cathedrals resulted from the use of structural elements as frank features of the composition of the cathedrals. Although classic architecture and Gothic architecture were radically different, the change from Roman to Romanesque to Gothic was actually a slow process of evolution. Not until recent times was another great concept of construction devised.

The Renaissance found a people who were dissatisfied with their own culture yet without enough faith in

St. John's College, Oxford, England, abounds with decoration

their own abilities to create a new architecture that would be expressive of their own aspirations. They reverted to the classic tradition, and with it the limitations of symmetry, the principles of emphasis of the horizontal or vertical direction, repetition of an element — particularly the column and the window, and the idea that some feature — a dome, a veranda, an entrance — should dominate a building.

How to achieve dignity, sublimity, monumentality — how to achieve some *effect* — these were the problems of the Renaissance. Like Roman architecture, Renaissance was a grandiose expression of an age of imperialism, an architecture that is still imitated, not only in kingdoms, but in countries with democratic and socialistic governments.

Renaissance might be classified as an art of decoration. As such, most of the progress Renaissance architects made was in adding variations to the classical façades until weird styles were developed for the sake of novelty. Architecture then degenerated into such periods as Rococo, Victorian "gingerbread," and Greek and Gothic revivals. The original problems dealt with in Greek and Gothic architecture were not solved in a new way. Architects lost sight of those problems and merely disguised structures with façades that revealed only unsympathetic use of two great styles. John Ruskin, famous critic of the arts, wrote around 1840 that "In the wild struggle for novelty, the fantastic is mistaken for the imposing, superfluity of ornament for beauty, and its total absence for simplicity." This was the industrial age, an age of science that saw learning and inventions increase without bounds. Philosophies no longer belonged to a race or an era or a generation, but changed with each new development. Architectural styles fluctuated with sympathetic vibrations — on again — off again. It was the style previously referred to as eclecticism. It still persists today. But is it what we want? Is it great architecture?

Egyptian, Roman, Gothic architectures are undisputedly considered great architectures. Rococo, Baroque, and Victorian styles, and Greek and Gothic revivals are usually considered periods of stagnation.

Three factors would seem to be involved in great architecture:

1. A unique problem to solve.
   It may be technical.
   It may be one of obtaining a desired effect.
2. A structural theory that solves that problem.
3. An aesthetic solution.
   It must not conceal the structural elements but reveal them as objects of beauty.
   It must express the character, ideas and philosophies of its creators and the people it serves.

New Problems to be Solved

Now what can be said about all these new styles which are combined under the heading "modern architecture"? Have there been any new problems solved in an appropriate manner, or any old problems solved logically in a new way? Is there a pleasing aesthetic solution to these problems?

With the industrial age came oceans of problems. What a golden opportunity for architecture — it thrives on problems! The industrial age forced people into cities, cities that had to grow vertically, for land became a more valuable commodity. The Bessemer process made steel plentiful. "Steel cage," from which walls were hung, outmoded the concept of weight-bearing walls. Here was a new problem (how to build multi-storied buildings higher) and a structural solution, the steel cage. All that was needed was an aesthetic solution that would not conceal the structure. Most early skyscrapers did have façades that concealed the structure; there were pseudo-Gothic, pseudo-classic, and pseudo-Romanesque styles that gave the false appearance of weight-bearing walls. Gradually these false styles disappeared, or only token reminders remained. Yet, there is not a skyscraper in existence that has fully achieved true structural honesty. The greatest (not necessarily the tallest) skyscraper has yet to be built.

But perhaps the greatest skyscraper never will be built, for as cities grow and blighted areas spread and

countryside decreases, the twentieth century, urbanized society begins to notice our lack of sunlight, our lack of fresh air, our crowded streets and unhealthy conditions. "Decentralization!" is the cry of America's city planners. "Air! Sun! Grass!" is the cry of the architects. Those are the problems: next, the structural concepts that modern architecture offers to solve those problems.

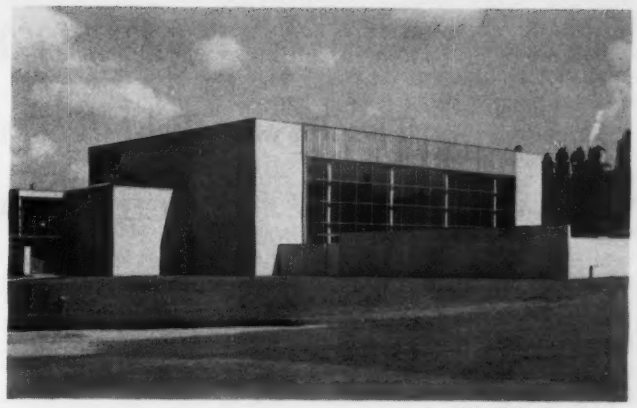
Ol' Sol is more troublesome in Brazil than in most parts of the United States, and it is there that many ingenious systems of blinds have been devised to regulate the sunlight at all hours of the day. More familiar to United States citizens, however, is the "solar eyebrow," usually an extension of the roof that lets the low winter sun in, but blocks the high, hot, summer sun from entering the rooms. Ventilization louvres are becoming increasingly popular. New emphasis is laid on correct orientation of rooms to catch the sun when wanted and to block it when not wanted, and to catch cool summer breezes and block cold winter winds. We are outdoor-conscious — everybody now wants a "picture window." Large expanses of glass have become a trade-mark of modern architecture. Planting is often taken inside the building. To gain a sense of continuity between floor and ground, a difference in ground level and floor level is often avoided. Utilization of the tensile-compressive properties of reinforced concrete has led to development of the cantilever, a means of extending a structure without support at one end. Flat roofs can now be made weather-tight, and glass panels can be used without great loss of heat. The whole field of plastics is unexploited.

It is easy to see the advantages of these advances in building construction. People want them, but one cannot put a solar eyebrow on a Colonial home, nor design a Georgian house with a picture window and louvres, for it is no longer a Georgian house (though this sort of thing has often been tried). For this reason architects are fortunately forced to abandon the escapism of eclecticism and once again become creative and not dependent on a handbook of styles.

Sociological Relations

That architecture was forced to break with tradition because technical advances cannot readily be adapted to conventional styles is true, but it is only part of the answer to why we have modern architecture. An architect is an artist, a poet; he likes to design creatively — not imitatively; he likes to express himself through his medium — building materials. The leaders of the new movement — Louis Sullivan, Frank Lloyd Wright, Peter Behrens, J. J. P. Oud, Le Corbusier, Walter Gropius, Mies van der Rohe, and many others — might be called sociological galvanometers; they indicated a new era of introspection. These men saw through the pretense, the shams, the unreasonable aspects of eclecticism. Great architecture *had* always expressed the ideals, the character and philosophy of the people it served and the architects who created it; but the eclectic period had architects who were equally at ease designing in Gothic, Georgian, or Queen Anne; people who might live in a Colonial home one year might occupy a Spanish villa the next. This must mean one of two things; either people's personalities changed from month to month, or they were living in an environment that did not express their ideals, their personalities, their aspirations. The former reason did not seem plausible; the latter did seem reasonable.

Great architecture is an expression of the people it serves. At the same time, the people are a product of their environment, part of which is their architecture.



The Technology Review

The Alumni Pool at M. I. T., designed by Lawrence B. Anderson, shows a noticeable lack of decorations

Then, if a certain style does *not* express the ideals and aspirations of the people, the people are having their own ideals, personalities, and aspirations influenced by ideals, personalities, and aspirations which are not their own. Architecture that causes this dilemma is dishonest, and a need arises for an honest architecture.

It was the need for an honest architecture that the pioneers of modern architecture tried to fulfill. Modern architecture is an attempt to achieve not only a utilization of the newest technical advances but also an expression of the life and philosophy of modern society.

"Modern society" — that is the cornerstone of modern architecture. Past eras may be labeled "Roman imperialism," "Greek individualism," "Medieval feudalistic collectivism," etc. But today we have "Modern ——" — we are at a loss for the right word! Today there is no tradition, nor is there a trend; it is a struggle, a struggle between collectivism and individualism.

The main struggles of modern architecture are also the struggles between collectivism and individualism. That accounts for our variety of styles. That explains why modern architecture cannot be explained as *a* trend!

The Extremes of Modern Architecture

Perhaps the best way to distinguish between the types of modern architecture is to differentiate the two extremes, the other types falling in between, occasionally being influenced by one extreme in one aspect and by the other extreme in some other manner. The two extremes are represented by Le Corbusier of France and Frank Lloyd Wright of America.

Le Corbusier was greatly influenced by the clean lines of ships, planes, grain elevators, and machines of all sorts. He saw that their beauty was due to their completely functional design, unmarred by decoration, shams, or pretenses of any sort. This led to Corbusier's famous concept of a house as a "machine for living". He designed buildings with sharp lines, smooth, white surfaces, and inorganic materials — stone, steel, glass, and concrete. This was the functional house; gone was all unnecessary bulk; why not build with lighter materials? By means of re-inforced concrete construction, columns could support the floors and roof, eliminating the use of walls as weight-bearing elements, so that they could be placed in any desired manner. Interiors could be then arranged more flexibly, so that exteriors could be simplified. Now the building could be "off the ground." Again machines influenced building design,

(*Continued on page 170*)

Harmony

The Physics Behind This Musical Phenomenon

By RICHARD W. SPENCER, '49

MUSIC is defined by Webster as "the art or science of pleasing, expressive, or intelligible combination of tones; the art of making such combinations, especially into compositions of definite structure and significance."

Some primitive forms of music had no set of discrete notes to adhere to throughout a performance. A musician might never hit the same note twice in a performance, although he might come very close to it.

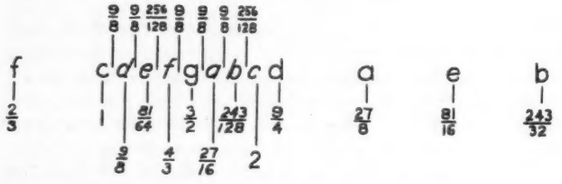


Figure 1. The Pythagorean scale, and the series of fifths of which it is built

Modern music (and by modern I mean all except the primitive forms mentioned above) is characterized by, among other things, the use of a succession of notes of definite pitch with fixed intervals between them, forming what is called a scale. Civilization has seen the use of several scales at various times and places. Before considering these, however, let us review a little elementary physics.

If two pure notes (no harmonics being present in either of them) are sounded simultaneously, a third note called the difference note is produced. The frequency of this note is equal to the difference between the frequencies of the two original notes, and can often be easily distinguished if its frequency is not below the lowest audible frequency. If the two original notes give a difference frequency which is below the audible range, or less than about fifteen cycles per second, no difference note will be heard, but the phenomenon known as beats is observed. As the two notes of nearly equal frequency become alternately in and out of phase, they alternately re-enforce each other and interfere, to give the pulsating effect described as beats. Beats are generally avoided in musical harmony, as the effect is unpleasant.

All musical instruments, including the voice, produce sounds which contain many frequencies. Besides

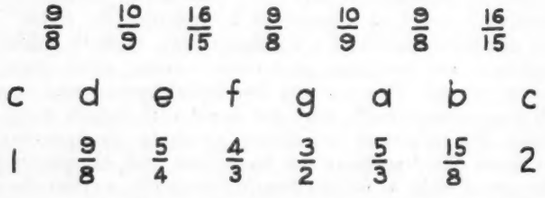


Figure 2. Our major scale of the key of C, showing frequencies relative to c and frequency ratios of the intervals between adjacent notes

the fundamental, or first harmonic, there are usually many higher harmonics. It is the number and intensity of the various harmonics which give an instrument its distinctive character, called *timbre*, which makes it sound different from other intruments, even when playing the same note.

Let us repeat our experiment, this time, however, playing notes on two musical instruments, not using the hypothetical pure tones we considered before. It will be found that most combinations of two notes will sound harsh or unpleasant. Beats will be heard where none were heard using pure tones. This is because of the addition of overtones (or harmonics). There are now present the two fundamental frequencies, the difference note, the overtones of both the original notes, and several possible difference notes arising from differences between overtones, or between an overtone and the other fundamental.

For example, notes of frequencies 300 and 199 cycles will sound unpleasant together if they have the usual overtones. The fundamentals are far enough apart to avoid beats, but the third harmonic of the 199 note (or

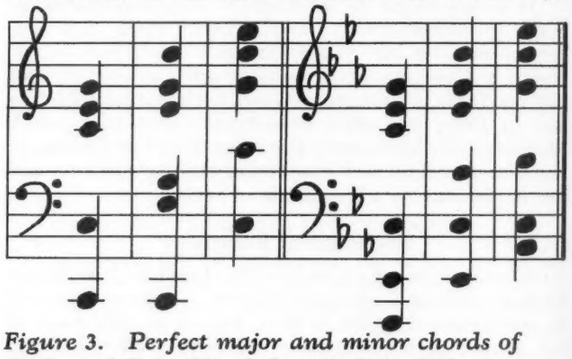
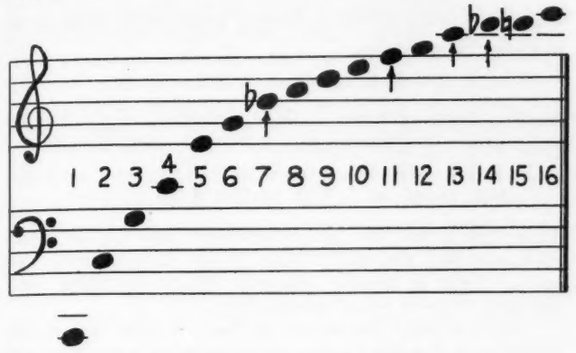



Figure 3. Perfect major and minor chords of the key of C (treble clef) and their difference notes (bass clef)

597) will beat with the second harmonic of the 300 note (or 600). The beat frequency is three cycles.

In this way, our possible consonant combinations of notes is greatly reduced. There are, in fact, rather few combinations of two notes which are consonant, the simplest one being the one whose frequency ratio is 2/1, an interval called the *octave*. The difference frequency is equal to, and therefore re-enforces, the lower note of the octave, and both notes have the same harmonics, the upper one being the second harmonic of the lower note.

Another interval, and the next simplest, is that having a frequency ratio of 3/2, which is called a *fifth*. The difference note (or more properly, the relative difference note, as it is expressed as the difference between the denominator and numerator of the fraction representing the frequency ratio rather than the absolute difference in cycles per second) is 3/2, or 1, which is an octave below the lower note. The harmonics of one are far enough removed from those of the other so that they will not beat.

From the fifth an interval known as the *fourth* is easily derived. It can be arrived at by going down a fifth from the original, then up an octave. Going down a fifth gives a ratio of $\frac{1}{3/2}$, or 2/3. Raising this an octave doubles the frequency, giving the ratio of the fourth, 4/3. Its difference note (1) is two octaves below the upper note (4) of the fourth. This is one of the few intervals whose difference note accentuates the upper note of the interval rather than the lower one.

The first sixteen harmonics of the C two octaves below middle C. The harmonics marked by arrows are not represented exactly, as there is no way to show them on the musical staff

The interval composed of notes whose frequencies are in the ratio 5/3 is called a *major sixth*. It is unique in that the difference note re-enforces neither fundamental. This difference note (2) is a fifth below the lower note (3).

A *major third*, ratio 5/4, has a difference note of 1, or two octaves below the lower note of the interval, 4.

The *minor third* is formed from the major sixth in the same way that the fourth was formed from the fifth. Go down a major sixth from the fundamental (1), giving 3/5, and raise it an octave. $3/5 \times 2 = 6/5$. This combination is not so perfectly consonant as the preceding ones.

The *minor sixth*, whose ratio is 8/5, formed by adding a fourth to the minor third ($6/5 \times 4/3 = 8/5$), is even less perfectly consonant than the minor third. The difference note, 3, is a major sixth below the lower fundamental, 5.

The ratio 7/4, the *harmonic seventh*, is considered dissonant by most musicians, and does not occur in our music. The harmonic seventh of a given note is the seventh harmonic of the note two octaves below the given note.

Other ratios, such as 9/8, 10/9, etc., composed of larger numbers, are definitely dissonant.

The intervals discussed in the preceding paragraphs are presented below in tabular form, in order of decreasing consonance:

	Name	*Frequency Ratio*
Perfectly consonant	Fifth	3/2
	Fourth	4/3
Consonant	Major Sixth	5/3
	Major Third	5/4
Imperfectly consonant	Minor Third	6/5
	Minor Sixth	8/5
Borderline	Harmonic Seventh	7/4
Dissonant	9/8	
	10/9, etc.	

It is seen that the simplest ratios are those of the most consonant intervals. This is in agreement with a theorem which states that the frequencies of two consonant notes are expressible as a ratio of small whole numbers.

Of course, the line between consonance and dissonance is rather vague. Furthermore, it has changed over the years. Before Mozart's time the minor third was considered too dissonant for use in music. The trend now is to use all the above listed intervals and more besides, some of which are admittedly very dissonant.

In order to play music which contains the above consonant intervals, it is necessary that the intervals between the adjacent notes of the scale be of such size as to permit the building of the consonant combinations mentioned above.

The early Greeks used a scale which was built upon only octaves and fifths. Using our musical notation, but bearing in mind the fact that the frequency ratios are not quite equal to the ones we normally use now, the Greeks built up a scale as shown in figure 1. Calling c the starting point, the scale is constructed as a series of fifths upward and downward as shown by the vertical lettering in the figure. The numbers below the letters in the figure are the frequencies of the various notes relative to c, which is taken as unity. As the ratio of the frequency of each note in this series of fifths to that of the note below it is 3/2, the frequencies of these notes are shown as powers of 3/2 when the note c is taken as 1. As laid out, these notes covered too wide a range, so they were moved into the same octave, as shown by the slant lettering. The development of this scale took place over a long period of time. Terpandro is responsible for introducing the a and the e, and the last fifth (b) was introduced by Pythagoras, whose name the completed scale bears. The numbers above the spaces between the notes are the ratios of the frequency of each note to that of the note below.

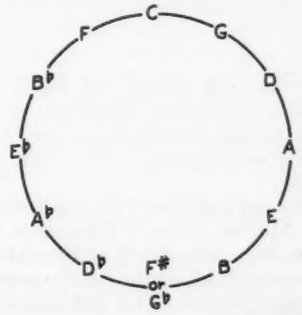


Figure 4. Circle of keys for equal temperament system

The Greeks were not the only ones who used successions of fifths to form a scale. The ancient Scottish and Chinese scales were composed of the first and second fifths above and below c, thus:

b♭ f c g d.

Again, these were transposed into the same octave. It is this scale which gives the old Scottish songs such a distinctive coloring.

As we might expect from the theorem of the ratios of small whole numbers, the Pythagorean scale has few consonant combinations of notes. The only ones which will be in consonance with the fundamental c (1) are f (4/3) and g (3/2), and, of course, octaves of these. While each note is consonant with the ones next to it

in the series of fifths, it becomes increasingly dissonant when played with notes farther from it. This scale held almost exclusive sway in Greece from the time of its adoption until the last century before the Christian era, when attempts were made to modify it to correct some of its shortcomings. These included the addition of as many as three other notes in some of the intervals in the Pythagorean scale, giving so-called quarter-tone intervals, which are now looked upon as very discordant.

The Pythagorean scale came to Italy, where it was the only one used up until the beginning of the sixteenth century, when developments began which were to transform it into our two present scales (major and minor).

The Greeks did go so far as to build other scales, using other notes of the original Pythagorean scale as their fundamentals, or starting points. All these were similar in that they contained the same intervals in the same order. For example, the notes of the g scale were all just a fifth above the corresponding notes of the c scale, etc.

The tenth and eleventh centuries saw great growth in the use of polyphonic music — music in which several melodies progress simultaneously. Frequent use was made of successive fifths, which was natural, as the scale was built upon fifths. This polyphonic music became excessively complex, and much of it is now considered worthless from the artistic point of view, being an artificial form built upon an artificial and imperfect

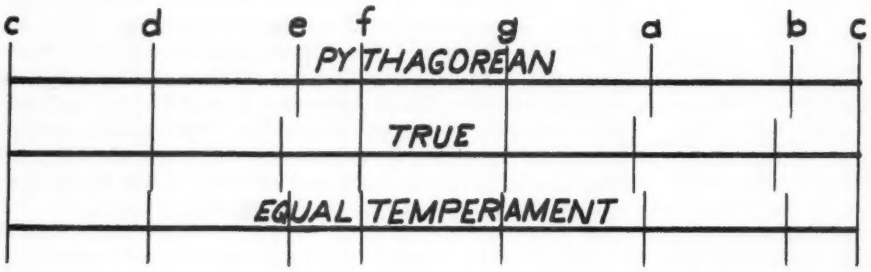


Figure 5

scale. There was, of course, no harmony possible, except the omnipresent fifth, which was used to such an extent that an average twentieth-century listener would listen to it only as a curiosity. However, it is interesting historically.

Music was sung principally by trained church choirs at this time. Martin Luther's Protestant Reformation put an end to this. The rising of Protestantism made necessary a new type of music which could be sung by untrained congregations. The polyphonic music was beyond the skill of the layman.

Minstrels and troubadours had laid the necessary groundwork by developing primitive melodies, from which sprang the popular songs and madrigals. Thus harmony began to replace polyphony. Palestrina was instrumental in bringing this movement into Italy.

Another idea which began to be developed at this time was that of the fundamental note and chord, and the related concept of a key or tonality about which a composition is centered. From these concepts developed our present major and minor scales.

Our major scale has notes of the frequency ratios shown in figure 2, taking c as the key note or fundamental. The figures below the notes indicate the frequencies of each note relative to c, and the figures above are the ratios of the frequency of each note to that of the one below it. It is seen that our major scale is composed of intervals of three classes; which are called *major whole tones* (9/8); *minor whole tones* (10/9); and *major semitones* (16/15), which are so named to distinguish them from another interval sometimes encountered called the *minor semitone.*

Referring back to figure 1, we note that the Pythagorean scale has only two intervals — whole tones (9/8) and semitones (256/243).

Our minor scale is built up of the same intervals as the major scale, but differently distributed, as follows:

9/8, 16/15, 10/9, 9/8, 16/15, 9/8, 10/9.

This gives notes of the following frequencies relative to c, again taken as 1:

1, 9/8, 6/5, 4/3, 3/2, 8/5, 9/5, 2.

Another form of minor scale is composed of the following relative frequencies and intervals, respectively:

1, 9/8, 6/5, 4/3, 3/2, 5/3, 15/8, 2;
9/8, 16/15, 10/9, 9/8, 10/9, 9/8, 16/15.

This scale is like the previous minor scale for its lower half, and like the major scale in the upper half. The second form is usually adopted when ascending, and the first is used when descending.

The essential difference between major and minor scales is in the third note, which is, with respect to the fundamental, a major third in the major scale, and a minor third in the minor scale.

With these scales it is possible to build chords of three notes or more. The two most important are the *perfect major chord* and the *perfect minor chord*, which are composed of a fundamental, its major or minor third, respectively, and a perfect fifth. In order that a chord will be consonant, it is necessary that each note composing it shall be consonant with each of the others. This is the case for both the above chords. Referring to the table of consonant intervals above, we see that the interval between the third and fifth of the above chords is a minor third in the case of the major chord, and a major third in the case of the minor chord.

Figure 3 shows each of these chords in three positions in the treble clef; the notes in the bass clef are the difference notes formed by the intervals of the chords. It is interesting to note that inverting a chord (moving one or more of its notes up or down an octave) changes the difference notes, changing completely the sound of the chord in some cases.

Similarly, chords formed of the fundamental, fourth, and major sixth; and fundamental, major third, and major sixth are perfect chords, inverted; the first a major chord built on f, and the second a minor chord on a.

At first glance, it would seem that the scales mentioned above should suffice nicely for all music. They do — if the music is all played in one key. But nearly all music modulates (changes to other keys) in some passages. This requires the addition of other notes to the scale.

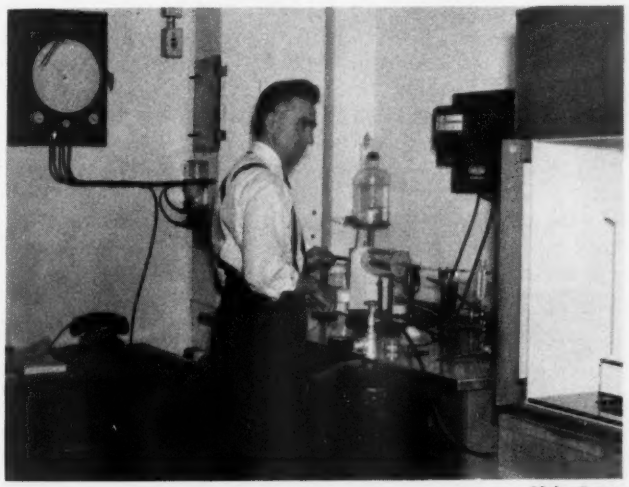
Suppose, for example, that we wish to modulate from the key of C to the key of G. (Keys are major keys unless otherwise specified.) We find that the intervals of the C scale are not in the proper order for a scale in the key of G. An additional note is needed a little above a in order to have a major whole tone as

(*Continued on page 172*)

The Microanalytical Laboratory of Today

By MARC L. ALFANDRY, '51

ONE of the noteworthy advances in organic chemistry has been the introduction of methods and procedures permitting chemical operations with exceedingly small amounts of material. This need was recognized in organic and inorganic research long ago, since many of the products of research, which can be isolated, are obtained only after great labor and in minute quantities. In those branches of chemistry dealing with toxicological, clinical and pathological problems the application of micromethods has been a necessity. The earliest contributions to microchemistry were made in the second part of the nineteenth century; in the opening decades of the present century enormous strides were effected in the extensive applications of the methods and techniques developed. The reason for the outstanding success of microchemical operations is that besides being as accurate as the macromethods, they involve great economies in time, materials, and laboratory space.



Myles Spector

A microcombustion furnace in use. On the wall over the furnace is the control and indicator panel

An important part of microchemistry is the field of microanalysis; the size of the samples analyzed has been gradually reduced from decigrams to centigrams and to milligrams as early as the beginning of this century. In 1911, Nobel laureate F. Pregl succeeded in revolutionizing most of the existing macrochemical methods in the quantitative analysis of pure organic compounds by the introduction of equivalent micromethods.

The M. I. T. microchemical laboratory restricts itself at present to the quantitative analysis of pure organic compounds. The various functions of the laboratory comprise the teaching of quantitative organic microanalysis under idealized conditions, the performance of analyses necessary for the research being carried on by the Department of Chemistry, and to a limited extent, to the performance of analyses for research workers in New England educational institutions.

The microchemical laboratory occupies at present three adjoining twelve by twenty foot rooms on the third floor of Building 2. Of these three rooms, one has been set aside to contain the hoods and is not air-conditioned; it is separated from the other two by a heavy glass-paneled door. This room was separated in order to eliminate complications in the air-conditioning system which is installed in the rest of the laboratory. The other two rooms are connected by an open doorway and are used as instruction and service laboratories. The instruction laboratory can accommodate four students at a time.

The laboratory has been laid out to incorporate the latest advances in design so as to obtain as far as possible idealized conditions. The service and instruction laboratories are air-conditioned and kept at a constant temperature of 72° F. The relative humidity is controlled and kept constant at 40 per cent. Dust particles are eliminated from the atmosphere by means of an electronic precipitator. Illumination is provided by fluorescent tubes fitted with reflectors. The windows are made of frosted glass which yields diffused daylight; this type of illumination is of considerable assistance when color determinations are to be made, as in the case of titrations. The floor is covered with asphalt tile and the ceiling is made of noise-absorbing cellular tiles. All the plumbing of the laboratory is concealed. The service laboratory contains equipment and desks for the director of the laboratory and his assistant.

The equipment of the laboratory is in keeping with its efficient functional architecture and embodies improved designs. Great attention and care have been given to the design of the benches so that maximum comfort and working efficiency could be provided for the benefit of the laboratory operators. The benches have been made functionally efficient by allowing knee space for the operators by means of cubical openings under the benches; in this fashion, the operators can sit close to the equipment placed on the benches in the

(*Continued on page 180*)

Micro-Kjehldahl distillation apparatus used in the M. I. T. microanalysis laboratory Myles Spector

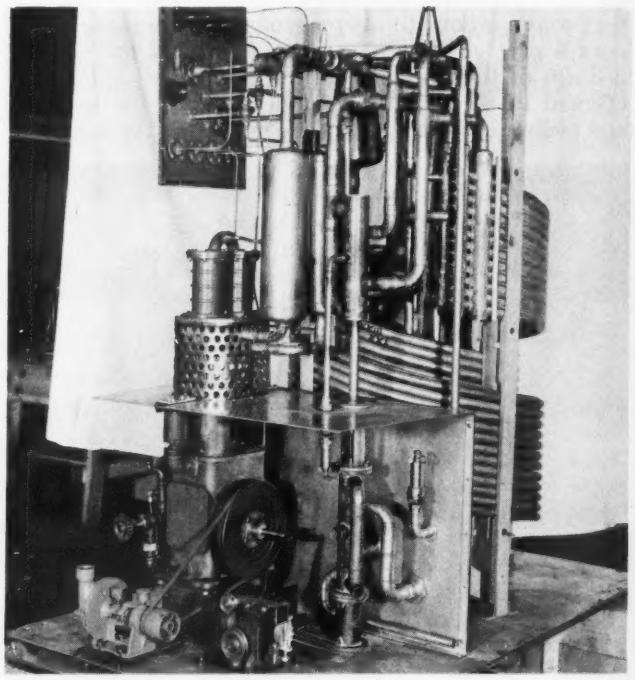
Industrial Oxygen

By CLARENCE GREGORY, '51

THE production of cheap oxygen has always presented a difficult problem to industry. Many processes, such as the production of synthetic gasoline from natural gas and the operation of the blast furnace, can be conducted more efficiently if oxygen gas of high purity is available. This has made the development of a cheap method of generating oxygen a major field for research during the past few years. When the war began, a means by which breathing oxygen for the crews of bombers could be manufactured during flight was desired. For this last reason especially, work on the development of a low pressure oxygen generator which would be small and which could produce pure oxygen was begun at the Massachusetts Institute of Technology. This work was conducted in the M. I. T. Physical Chemistry Laboratory under the direction of Professor Samuel C. Collins of the Mechanical Engineering Department.

The final improved generator produced by the laboratory operates, save for one exception, according to a method basically the same as that devised by Claude at the beginning of the twentieth century. This method involves the distillation of liquid air. One part of the apparatus, the air compressor, operates at room temperature; the other, the still in which liquid air is separated into its principal components, functions at a temperature of almost 300 degrees below zero F. Between these two extends the all-important counter-flow heat exchange system in which heat is absorbed from the incoming warm compressed air by the outgoing cold waste nitrogen and pure oxygen product. The compressed air arrives at the distilling column only a few degrees warmer than the nitrogen and oxygen leaving it. The waste nitrogen and pure oxygen emerge from the warm end of the heat exchanger only a few degrees colder than the compressed air entering. To cool the equipment to the operating temperature level initially and compensate for the heat leak through the insulation, thereafter, an expansion engine is provided. It is motivated by compressed air just as a steam engine is by steam. External work is performed at the expense of the internal energy of the air. The expanded air is discharged from the engine at a lower temperature than that at which it entered.

One of the problems in the liquefication of air has been the removal of high boiling impurities. These include water, carbon dioxide, and lubricating oils from the compressor. These substances condense on the walls of the cooling system, and obstruct the flow of air. The first solution to the problem was the use of chemicals which would absorb these impurities. Later, cold accumulators, vertical towers containing strips of metal of great heat capacity, were developed. Two currents of gas passed through each tower alternately in opposite directions. Two pairs of these towers were used in each oxygen-producing unit. In one pair compressed air and waste nitrogen flowed while compressed air and oxygen passed through the other pair. Cold nitrogen or oxygen flowing for a short period of time through one of the towers sets up a temperature gradient in the tower packing and becomes warmed to room temperature. During the next half-cycle compressed air flows in the opposite direction and becomes cooled by contact with the cold packing. The packing serves as storage for the heat or cold. Impurities deposited on

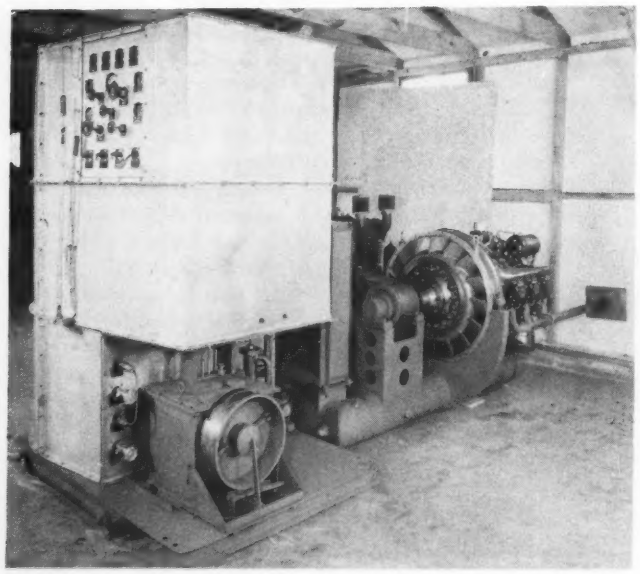


S. C. Collins

An exposed view of the oxygen generator. The coiled tubes in the background are part of the heat exchangers. Note the expansion engine in the lower left-hand corner

Complete industrial oxygen apparatus with the generator in the foreground and the air compressor in the background

S. C. Collins

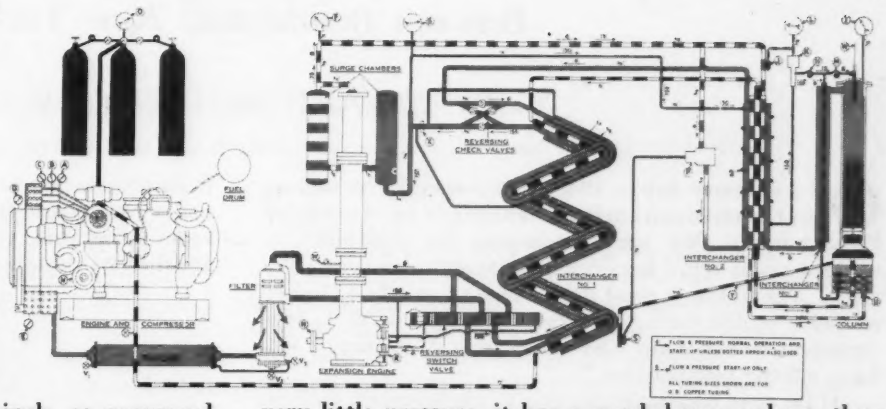


the packing while the compressed air is flowing are carried away during the next half-cycle by the oxygen and waste nitrogen which have a greater capacity for absorbing impurities in vapor form because of their lower pressure and consequent greater volume. However, this contaminated the oxygen produced and made chemical purification of part of the air flow necessary in some instances.

The research carried on at M. I. T. yielded two new improvements in the system of generating oxygen. They are properly identified as the reversing exchanger and the flexible rod expansion engine. These inventions have proved efficient enough to permit the operation of the oxygen generator at from 80 to 175 pounds per square inch, as compared with 500 to 3000 pounds per square inch used in nearly all existing equipment. In addition, oxygen of extremely high purity is obtained without any further purification.

The reversing exchanger differs from the cold accumulator in that the outgoing stream provides the heat capacity to absorb the heat contained by the incoming air so that no heat is stored in the metal. The reversing exchanger can be made much lighter and more compact than the cold accumulator. It usually contains three coaxial tubes which can transfer heat to each other readily. Compressed air flows through one of the annuli and is cooled by the return flow of cold waste nitrogen in the other. Oxygen flows in the central tube. Water and carbon dioxide, the usual impurities, condense on the walls of the annulus carrying compressed air. In a short time the valves automatically shift, permitting waste nitrogen to pass through the channel which has been coated by impurities. Since the nitrogen is under very little pressure, it has a much larger volume than the compressed air. Therefore it readily absorbs the condensed impurites. In this way the nitrogen clears one channel while the other is being contaminated. The reversing exchanger thus removes impurities from the air while the air is cooled.

FLOW DIAGRAM
AIRCRAFT OXYGEN GENERATOR, AIR BORNE



Much care must be taken in the construction of the reversing exchanger. A large number of fins are provided to insure enough surface for heat transfer and for the condensation of most of the carbon dioxide and water. Each of the two annuli must have the same cross-sectional area and must present approximately the same resistance to flow. These requirements are necessary to keep the pressure in the distilling column at a constant level when the valves are switched.

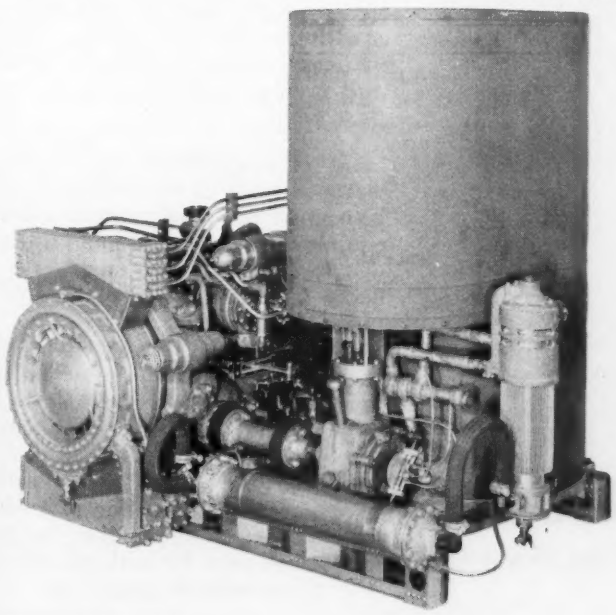
The Claude expansion engine, which has now been in use for forty years, is a low-speed machine of great weight per unit capacity. The piston is sealed by a leather cup similar to that used in a tire pump. It operates without lubrication. Because of the friction between the leather cup and the cylinder wall and the heat conduction along the massive support members, the Claude engine is of only moderate efficiency. Later machines have been equipped with non-metallic piston rings instead of leather cups with similar success. Kapitza designed an engine for very low temperature service in which neither cup nor rings are used. To prevent excessive leakage, the power stroke was made in a very short time with a more leisurely return stroke. The motion was controlled by hydraulic means. Although the engine was very successful in performing its intended service, it was too complicated for commercial applications. Professor Collins, however, was able to design a piston and cylinder which fitted with ten times the pressure tightness of previous models. Nitralloy pistons and cylinders of great hardness operate without leather cup or rings and with almost no leakage. This was made possible by placing the expansion chamber beneath the piston head so that the piston rod is under tension instead of compression. This permits the piston to center itself in the cylinder without scraping the cylinder wall. Nitralloy is subject to little wear; engines have been used for 6000 hours without signs of scoring.

The actual process of oxygen production in the M. I. T. generator begins with the compression of air to 150 pounds per square inch. The efficiency of heat conservation in this system is great enough to permit operation at very low pressures. From the compressor

(*Continued on page 176*)

This oxygen generator complete with air compressor and gas engine stands only three feet high and weighs only 475 pounds; yet it can produce 150 cubic feet of oxygen gas per minute. It is the smallest unit of its kind having such a large capacity that exists

S. C. Collins



Boston to New York in Eight Jumps

American Telephone and Telegraph Company Installs a Radio Relay System Between Boston and New York

By EDWARD MULLERY, '48

ON a summer day in 1941, I happened to be talking to the communications manager of an Associated Press bureau. We were discussing the possibility of using a radio relay network to transmit teletype messages. "It will be a great day," he said, in effect, "when someone builds such a network. Then A. T. & T. (the American Telephone and Telegraph Company) will have a little competition."

If he were counting on such a development, then he must have been sorely disappointed when the telephone company announced last November, with an appropriate flourish of newspaper advertisements, that it had completed the first permanent radio relay installation in the country, between New York and Boston. Thus A. T. & T. appears to have the new field well under control.

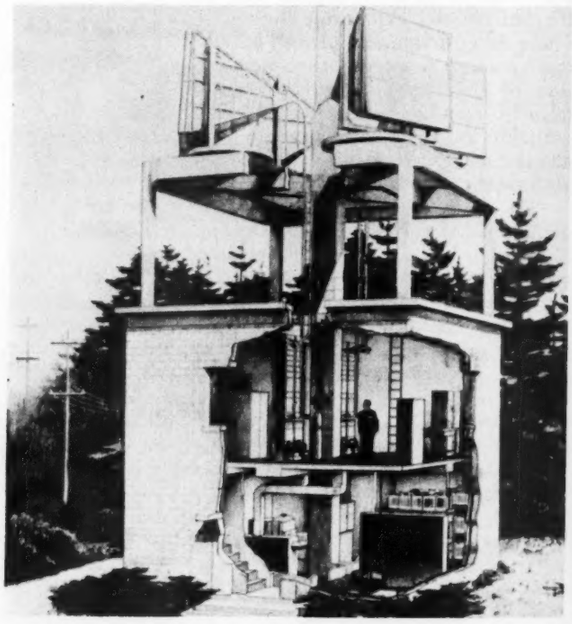
Radio relay systems such as the one between Boston and New York have two purposes. One is to transmit the same sort of messages which are handled by ordinary telephone lines. The other is to transmit television programs between stations; this cannot be done by ordinary telephone circuits.

In handling the usual type of long-distance communication, such as telephone and teletype messages, a radio relay system is tremendously effective. By using the carrier-wave principle, such a system can handle hundreds of messages at once. The initial installation of carrier equipment on the Boston-New York system will handle 240 simultaneous messages, and it is expected that more channels will be added later.

But it is in the transmission of television programs from one station to another that the radio relay system really comes into its own. Television programs, unlike radio programs, cannot be sent from one station to another by telephone lines. They require such a wide band of frequencies that special methods have to be used for their transmission. Present radio relay equipment has a signal band width of approximately five megacycles; hence it can easily handle a television broadcast.

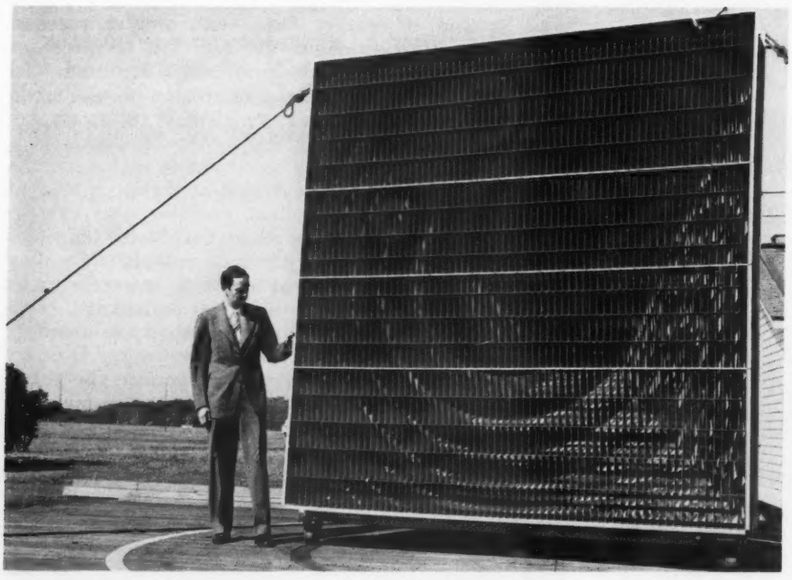
As the television networks of the country expand, more radio links will undoubtedly be built; but they will have to prove that they can compete, economically, with an alternative means of transmission — the coaxial cable. Such a cable can handle wide frequency bands and can be used for both television

(*Continued on page 174*)



A. T. & T.

A cut-away sketch of type of relay station used between Boston and New York. Microwave antennas on the roof receive and transmit the signal. The radio equipment is on the second floor while emergency power facilities and storage batteries are on the first floor.



Close-up of the new type microwave antenna used on Boston-New York radio relay system

Germany—1947

Experiences of a Civil Engineer with the United States Army in Europe

By WERNER H. GUMPERTZ, '48

Formerly Structural Engineer, Office of the Chief Engineer, European Command, United States Army

THE luminous dial of my wrist watch shows midnight, the hour of ghosts. The headlights of my jeep transform a hundred yards of superhighway into a glaring white band, stretching through plains, across hills and over rivers for mile after mile. The humming of the motor seems to have a strange effect on my eyes: they keep on closing. Then I remember the automobile accident witnessed on the previous day. My eyes stay open. I cover mile after mile; no soul is to be seen. Suddenly, I blink my eyes. A human figure stands in the middle of the road, gesticulating wildly. A man? No, a woman. The jeep slows down and finally stops.

"Please, I can go mit you in the car, yes?"

"Where do you want to go?"

"Frankfurt!"

"All right, hop in!"

The jeep starts with a jerk and then gradually gains speed. Neither one of us talks. My companion stares straight ahead, clutching a small suitcase in her hands. Something in the expression on her face makes me think of a lecture on the German underground movement. The lecture had not aroused my interest too much at the time. Now my right hand leaves the steering wheel and fastens around the .25 caliber pistol in my coat pocket.

"You American, yes?"

I am about to admit that I am, when I recall a detective story I read some years ago.

"No, I Russian officer, liaison with American Army."

I hope that I sound like Serge Ivanovitch from Dnepropetrovsk. My accent seems to pass the test.

"Oh, you Russian. Good! I not like Americans. I like Russians. Russians good soldiers. Americans always afraid, yes?"

"Mmmm . . ."

"Soon, Russians come to American zone of Germany and throw stupid Americans out, yes?"

"Mmmm . . ."

"Then, Russians stay and make Germans happy, yes?"

"Mmmm . . ."

"I very clever, I help you against Americans, yes?"

My talkative protégé gives me a big smile. The manner of her approach obviously does not bear out the first part of her statement. The second part, however, cannot be questioned in its sincerity. The problem thus confronting me as a representative of the United States Occupation Force appears to have but little resemblance to my previous experience, which had been confined to twisted steel girders, blasted bridge foundations, and destroyed railroad tracks. Once more, the old detective story is called to help. What did the hero do at a comparable stage of the game? Why of course: after ingeniously trapping the law-breaker, he took her to the nearest police precinct and greeted the desk-sergeant with the sarcastic statement: "Here she is!"

Werner H. Gumpertz standing beside one of the many German roads he travelled

My companion seems to feel as safe as if she were on the market square of Voroshilovgrad. Minutes later, I turn off the superhighway. The self-styled Graschdanka is becoming nervous:

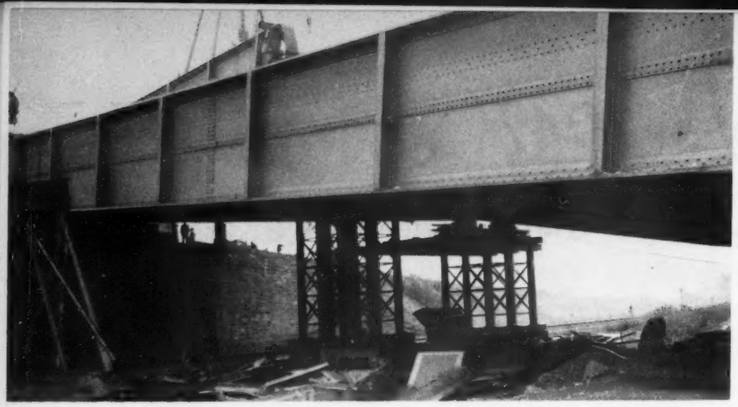
"Why not go on, please?"

"I want to give you a chance to talk a little more about those big plans of yours."

This oracular answer seems to put her at ease — temporarily. When we pull up in front of a German police station, her attitude

The lower right shows the twisted northern end of the Karlsruh bridge. The main girder has broken off near the first intermediate pier seen at the upper right of the picture.

333d Engineer (S.S.) Regiment



333d Engineer (S.S.) Regiment

Temporary steel piers are prepared for the purpose of jacking the slanting bridge back into position

changes so considerably that I have to firmly assist her into the building. The German desk-sergeant listens to me and nods sympathetically:

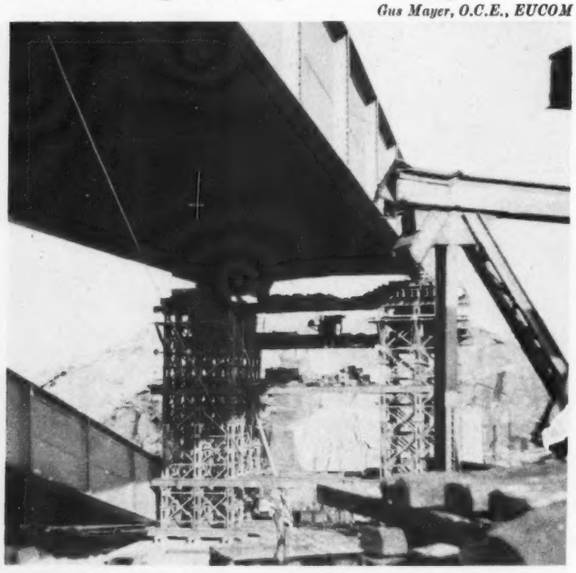
"Ja, ve vill hold her iff you wish."

I do wish. I give the policeman instructions to harbor his new guest until I can notify the Military Police. My would-be ally shouts a string of doubtful compliments at me while I drive off.

Hours later, I sit down at my desk in the Office of the Chief Engineer, European Command. This office is located in Frankfurt, Germany. Its staff is responsible for construction activities in the United States zone of Germany carried out under the supervision of the United States Army. One branch of the office, charged with direct supervision of construction work, has a number of civil engineers who conduct periodic inspections of pending projects. This group of inspectors is quite international in character, comprising an Englishman, an Estonian, a Frenchman and a number of men from Holland, Belgium and other countries. One of them even hails from Brooklyn. An inspector might be confronted by problems dealing with any phase of engineering. (My experience related above indicates that problems of a different nature arise occasionally.) Within a short period of time, he may be called upon to work on projects involving bridges, highways, warehouses, hospital rehabilitation, water supply and sewer systems, stone quarries, troop housing, electrical ring lines, airports, and drainage problems of hard standings. Inspectors have no command function but their responsibility is considerable, since the Theater Chief Engineer acts on their advice. Many small problems are straightened out in the field without ever going through army channels. The taking of such decisions gives the inspectors great opportunities to gain firsthand experience on construction problems.

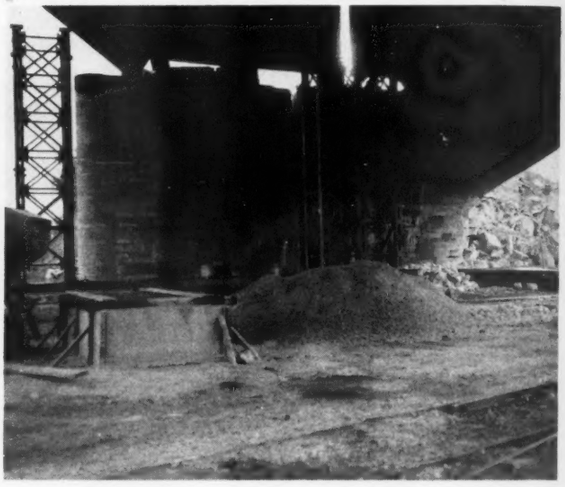
The right-hand bridge has been lifted and awaits construction of the northern abutment. The twin bridge on the left is still on the ground

Gus Mayer, O.C.E., EUCOM



Traveling is fairly simple. Transportation is effected by jeep, usually driven by the inspector himself. Army Messes and Transient Hotels are available in all major cities, and military units in small towns have their own facilities.

Once installed at my desk, my mind wanders back to my nocturnal experience. The telephone rudely interrupts my thoughts:



333d Engineer (S.S.) Regiment

The southern abutment, damaged on the right and leaning into the foreground, has one of its supports entirely gone

"This is Schlenker calling from Dachau!"

"What's up, Schlenker, are you worried about that old open-joint water line again?"

"No, I want to see you about that new roof truss for the Officers' Club. The design came from the Munich Area Engineers' Office, and it looks strange to me. I wish you could come down here."

"O.K., I'll try to get there as soon as possible; I know that Colonel Cole wants that building finished in a hurry. In the meantime you can go ahead and have a test beam prepared."

I walk over to the desk of my section chief.

"Steve, Schlenker is in trouble about those new trusses. I would like to go and see what's wrong."

"All right, go ahead. Take a look at the Autobahn ' idge in Karlsruhe on the way, and I understand there is something funny about the Neckar River bridge near Stuttgart. And the Intelligence Training Center at Oberammergau needs a technical inspection. How many days will you need, approximately?"

"I'll be back early next week, if nothing goes wrong. I hope the jeep won't break down as many times as on last week's trip."

I go from the office to my room and pack my musette bag. Ten minutes later, I am back at the steering wheel, driving toward Karlsruhe.

Autobahn Association

A general view of the destroyed Neckar River Bridge and the emergency bridge constructed on it, taken during a high-water period

Karlsruhe is reached in two hours on the Autobahn. The bridge spanning the Karlsruhe railroad yards is a continuous plate girder twin bridge, consisting of three unequal openings. Material used is the famous "St 52," a steel with an ultimate strength of 74,000 lbs./sq. in. Because of the relatively small moment of inertia, the girders have a greater deflection than usual. The two end abutments have been blasted. The northern one has crumbled completely, causing the downfall of the bridge end and rupture of the main girders close to the adjoining intermediate pier. The southern abutment has been blown from its base and is leaning toward the inside. The bridge girders are dislocated from the bearings and rest on the leaning concrete pier in a haphazard fashion.

Driving by, I remember the difficulties connected with the reconstruction of this bridge. One problem is presented by the twisted northern end of the bridge itself. The end cross beam, the stringers, and the intermediate cross beams underneath have formed a very stiff cellular network, holding the main girder in its twisted shape. The German engineers plan to cut off the entire end of the bridge, replacing it with the end of the parallel twin span which is to be abandoned. It appears, however, that this procedure will mean a considerable waste of time because of the complicated cutting and replacing processes involved. Thus, I suggest that the main girder be disconnected from the lateral braces and be straightened out without the application of heat. This method was used and resulted in the speedy and satisfactory repair of the damaged end. The southern abutment, leaning dangerously, appears to be held up only by the weight of the bridge resting on it. Temporary supports for the bridge are already in preparation, so that the girders can be lifted off the piers and set back on the proper level.

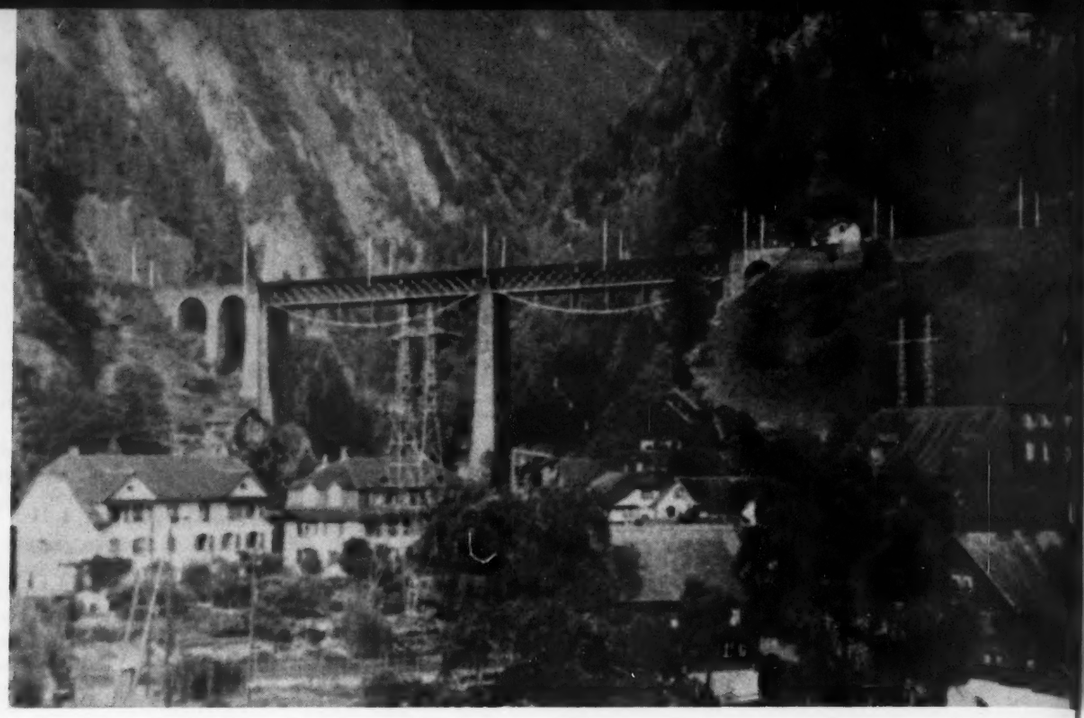
In a meeting with the American officer in charge and his German assistants, we discuss the various problems. After obtaining routine statistical information on the project, our attention turns to the main engineering problems, especially that of the leaning abutment. The resident engineer intends to raise the end of the bridge from the pier in order to attempt to set the broken abutment back on its foundation in a vertical position. This is a very daring undertaking since it can not be ascertained in advance whether the leaning pier is not held upright solely by the weight of the bridge resting on it. However, this plan was eventually carried out successfully with the help of hydraulic presses and a complicated system of steel rolls. Today, the pier is doing full service again, supporting the original bridge which has been repaired and straightened. After taking some short notes I proceed to Stuttgart where I stay overnight. The evening in the hotel is used to write the official report about this bridge.

Early next morning I proceed to the Neckar River Bridge where "something funny" is supposed to be going on. That is decidedly an understatement. The "bridge" is a wooden emergency structure built on top of the original reinforced concrete structure which had been blasted by retreating German troops during the last days of the war. Most of the rubble is in the water and forms a very poor foundation for any kind of bridge. Consequently, the wooden superstructure had settled considerably until it looked as wavy as the ocean. Intermittent floods of the Neckar River had speeded up the settling process, so that finally somebody had erected a third bridge on top of the second one to keep the roadway level. The settling continued, however, and maintenance crews had erected obstacles on alternate sides of the bridge deck to force all vehicles to slow down. The whole contraption looks like Rube Goldberg's nightmare. With some apprehension I begin to examine the structure from underneath. The stringer I-beams are supported by cross beams. One of these cross beams is held on the slanting deck of the destroyed bridge by a block of concrete. A great crack

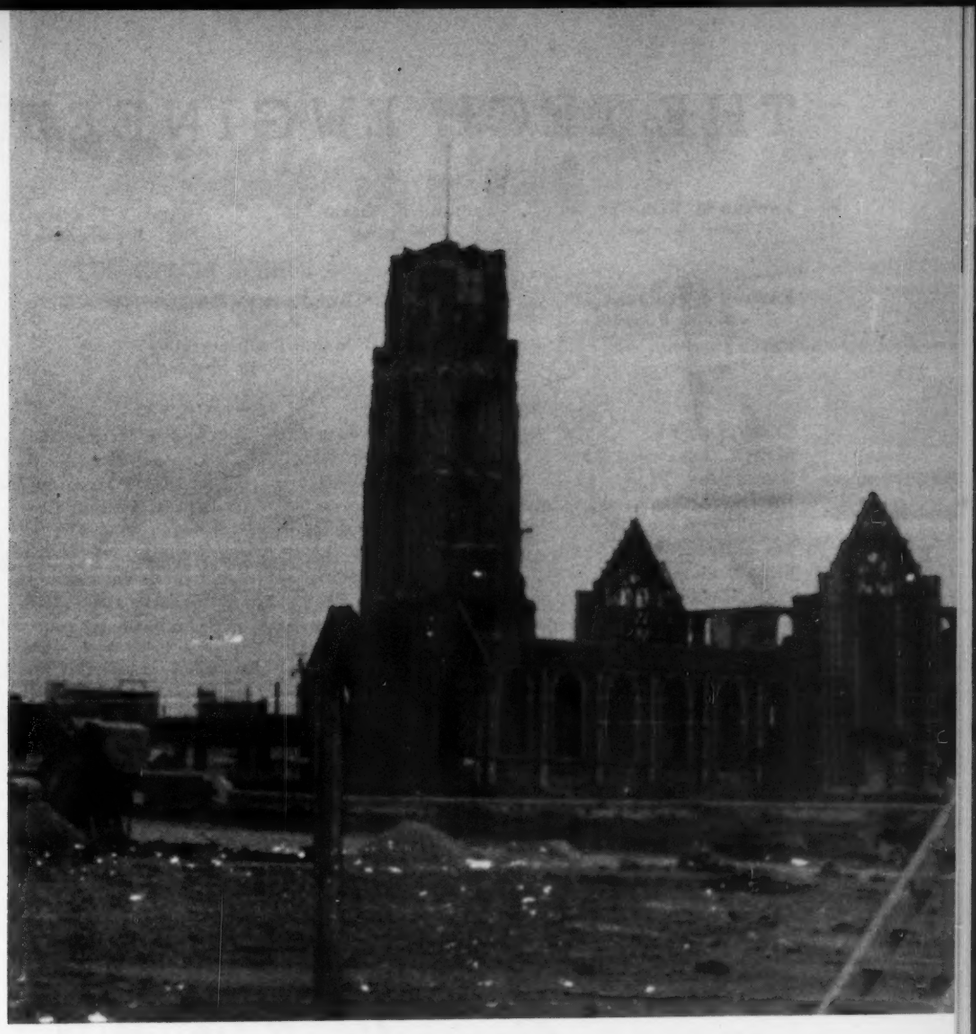
(*Continued on page 162*)

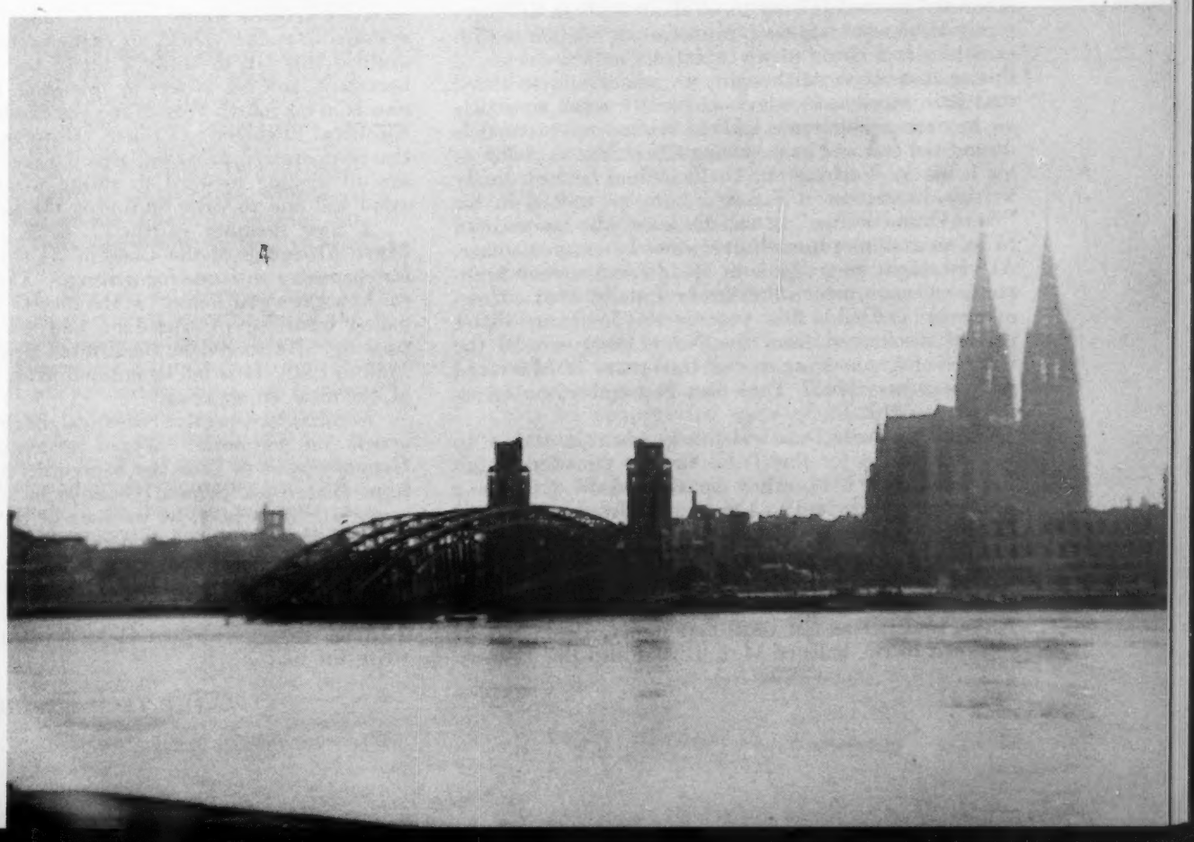
A counterbalance used on the Neckar River Bridge to hold one of the arches and counteract the one-sided thrust until the neighboring arch had been reconstructed

Autobahn Association



Directly above is a view of a Swiss bridge. T
one on the Gotthorel railroad crosses a side v
near Amsteg. To the right of this we see w
used to be the business center of the Dutch sea
of Rotterdam before the Nazi planes gave i
taste of German "culture." Below this view
Rotterdam is a scene of war-torn Cologne. T
famous cathedral, though burned out, rema
standing, but the Nohenzollern Rhine R
Bridge lies in the river.
In the lower left-hand corner appears a pictur
the cogwheel train near Garmisch. It is j
about to enter the long tunnel leading up to
summit of the Zugspitze. Below is the floa
trolley travelling above the Wupper River
Germany.





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From the Editor's Notebook

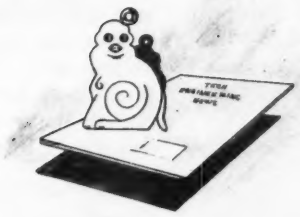
A while back, **Dick Ahern** dropped into the *T. E. N.* office and started talking to us about modern architecture. As he went on, always illustrating his points with examples and citing many architects as proponents of this or that school of thought, we immediately realized that here was a man who could really write an article on modern architecture. Dick worked on his article during the fall and even during Christmas vacation at his home in Washington, D. C. When he had finally written it so that it satisfied him, he turned in his "New-Found Forms" to us. Dick says he has wanted to be an architect himself ever since he can remember. As you might guess, he is in M. I. T.'s five-year Architecture Course, which finishes in June of 1951. However, this is Dick's first year at the Institute. After getting discharged from the Navy Dick entered the College of Engineering at the University of Maryland in September, 1946. Then last September, he transferred to M. I. T.

Dick Spencer, an old-timer when it comes to writing articles for the *T. E. N.*, first joined the staff back in July, 1944, when he entered M. I. T. as a Freshman. Dick had just graduated from high school in his home town of Winchester, Mass., but it did not take him long at Tech to become one of our authoritative authors. His first piece of work was on radio signal systems. In February, 1945, Dick joined the Navy, and it was not until September, 1946, that he returned to the halls of M. I. T. and also the *T. E. N.* office. Immediately he started writing again. We received articles whose subjects ranged from heating systems to radar. Dick, an enthusiastic piano player, decided this fall to study a bit of the physics behind harmony, and his article in this issue resulted. Dick now is in his fourth year in the electronics option of the Electrical Engineering Course. However, since he is in the co-operative program, which takes five years, we are all looking forward to seeing what else his agile mind will find to write on during the next year.

A new member of the *T. E. N.* Literary Staff, **Marc Alfandry** of the Class of '51 combined a liking for chemistry with one for writing. "The Microanalytical Laboratory of Today" is the result. Marc originally hailed from Egypt where he had all his pre-college training. He served in the United States Army from 1946 to 1947. Last fall he entered M. I. T. as a student of chemical engineering.

Another prospective chemical engineer wrote the article on industrial oxygen generators. **Clarence Gregory** came to Tech last September after graduating from Brunswick School, Greenwich, Conn. While a senior at that school, he was one of the forty national winners in the Westinghouse Science Talent Search. His prize winning paper was entitled "Molecular Weight Determination by the Boiling Point Method." With such a recommendation for Clarence, we of the *T. E. N.* were more than pleased when he decided to write for us.

The Dragon's Den



Where Are We Going? . . .

Controversial issues are always coming up, and we are called upon to take a stand one way or the other. However, there is more to it than merely deciding whether or not we are in sympathy with the particular method of handling a problem that confronts us. It is vitally important to classify problems as to how crucial they are. The evaluating must first come on this level, because action for meeting one perplexing issue may well interfere with that designed to meet another. All too often sufficient time and thought is not given to deciding the urgency of the various issues. Thus a man may feel called upon to support the demobilization of the armed forces and at the same time wish that the United States take an active part in maintaining international peace. Though he believes in both ends, should the methods used to attain either exclude the other, then he must decide the relative importance of each issue.

Along these lines, there is real cause to re-examine the order in which critical issues, now facing the people of America, are placed. As citizens and as future leaders, we students at M. I. T. should try to decide what kind of a country as well as what kind of a world we wish to live in. It can not be denied that the international situation is serious and it presents many disturbing problems. We certainly hope that the spirit of isolationism will never again take hold of the American people; but we still ought to consider how we take part in world affairs.

The present fear of future wars and of nations likely to start such wars is one of the strongest forces working on the American scene right now. The major nation whose motives we doubt and whose military power we fear is, of course, Russia. There may well be just cause for some of this, but the psychology of fear is a dangerous thing in itself. It puts us on the defensive right off and hinders constructive thinking. It takes a hold on the mind which is far stronger than its importance alone should allow.

Aside from the fear itself, what action is it driving us to take? Should we have to drop action on domestic issues and give up certain valuable attributes of the type of society we are trying to protect, we shall have lost already. If it is necessary to turn the United States into a military nation in order to protect a way of life where the individual counts, is not that admitting our loss? If the victory is worth attaining, there must be other ways of winning it than by adopting the techniques of those we wish to defeat. It is not enough to say that the end justifies the means, for if the means excludes some other end we desire, we have gained nothing.

Four Years, Then? . . .

Deciding the order of importance of problems is not limited to the Tech student as a citizen of the United States; it is also part of his daily routine. Quite often as a student, he is called upon to do more than he is physically able to do well. The situation arises where he must decide what is important and worth while. The faculty may bear most of the burden of deciding how the student shall spend each day. Yet every day he decides to a certain extent where he shall allocate his time, and this should be more than just a daily process governed by which subject has the next quiz. Whether you are at M. I. T. to obtain an education which is sufficiently well-rounded for your purposes or whether you are here merely for the professional training, it is absolutely necessary that you look to the future and decide what type of person you wish to be at the end of four years at Tech. If you leave to the faculty the complete decision and responsibility for what type of man M. I. T. turns out, you may be disappointed when graduation comes. Making your own decision as to what you want to get out of your four years of college may cost you something in the way of your cumulative or your social life. Be that as it may, there should be more behind your decision on how to spend your nights than which home work assignment is more pressing or which girl you most wish to see.

E. T. M.

GERMANY — 1947

(*Continued from page 157*)

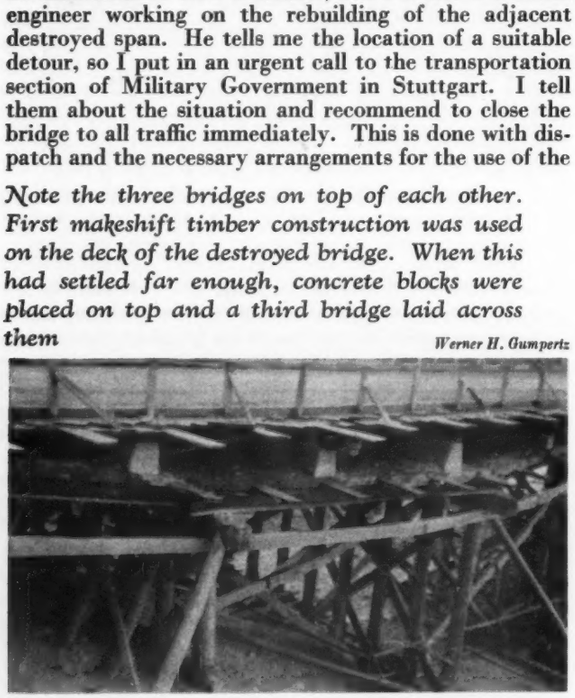
runs through that block from the edge of the I-beam to the other side, indicating shearing action, while the I-beam itself is slanting already. It appears that the next heavy truck might cause the block to shear off completely and bring the whole bridge crashing down. On the other side of the bridge the timber bents had also been built on the deck of the original bridge. Closer examination of that deck reveals that it is supported on one side in a precarious fashion by some pieces of broken concrete, mostly by virtue of friction between the various pieces of rubble. The other side rests in the muck of the river bed. Other parts of the bridge do not look much more trustworthy. There is no maintenance crew available, but I locate a German engineer working on the rebuilding of the adjacent destroyed span. He tells me the location of a suitable detour, so I put in an urgent call to the transportation section of Military Government in Stuttgart. I tell them about the situation and recommend to close the bridge to all traffic immediately. This is done with dispatch and the necessary arrangements for the use of the detour are made. In a subsequent conference I suggested that a Bailey bridge be erected with better pile foundations, to accommodate the traffic until such time when the permanent structure could be completed. Upon request of the Military Government engineer I made arrangements for the loan of the necessary Bailey bridge panels and some heavy equipment not available to Military Government. Work had to be done fast, as the flood period of the Neckar River was approaching and the rubble in the river channel would obstruct the flow of the water thus causing scouring under the bridge abutments. Actually, during later inspections it was possible to have the debris in the channel removed just before the spring floods set in, thus avoiding further damage. Presently, the Bailey span was installed, giving satisfactory service until the completion of the permanent bridge.

Werner H. Gumpertz

The big piece of debris from the destroyed Neckar River Bridge is settling into the river bed, and the I beam supporting the stringers is only precariously held by a piece of concrete which is visibly cracked

Note the three bridges on top of each other. First makeshift timber construction was used on the deck of the destroyed bridge. When this had settled far enough, concrete blocks were placed on top and a third bridge laid across them

Werner H. Gumpertz



A view of the western abutment of the Neckar River emergency bridge before settling began

Autobahn Association

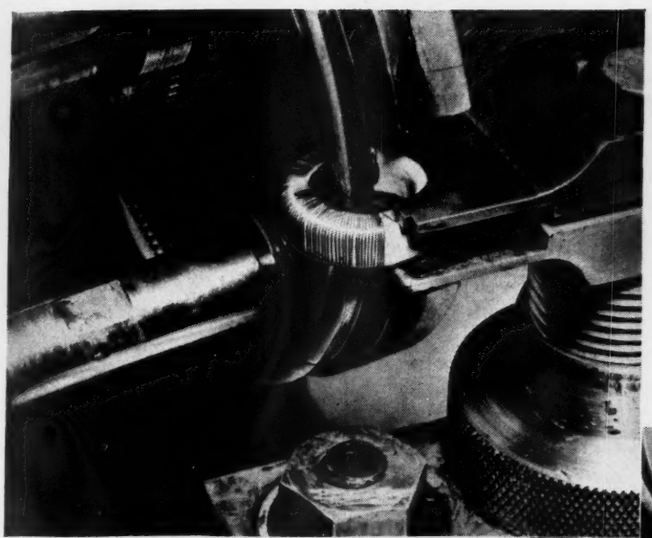
The next stop is Dachau, about one hundred miles to the southeast. The former concentration camp at Dachau is now used to detain German bigshots. Many of them are being tried here by United States Military courts for crimes against humanity. It is strange justice that these trials should be held in the camp where Germans have committed the most revolting atrocities for almost twelve years.

Mr. Schlenker, the post engineer, whose telephone call started me on this trip, had been in command of one of the combat engineer units that had captured Dachau. Due to the trials being conducted here and the establishment of a prisoner of war discharge center, the staff of the camp has increased considerably and an annex to the officers' mess has become necessary. The office of the Munich Area Engineer (a unit subordinated to the Office of the Chief Engineer in Frankfurt) has designed the annex, and construction has now started after considerable delay due to changes in procedures for project approval. The roof truss of the annex to the mess hall must be very low in depth so as not to obstruct some windows on the second floor of the main

(*Continued on page 164*)

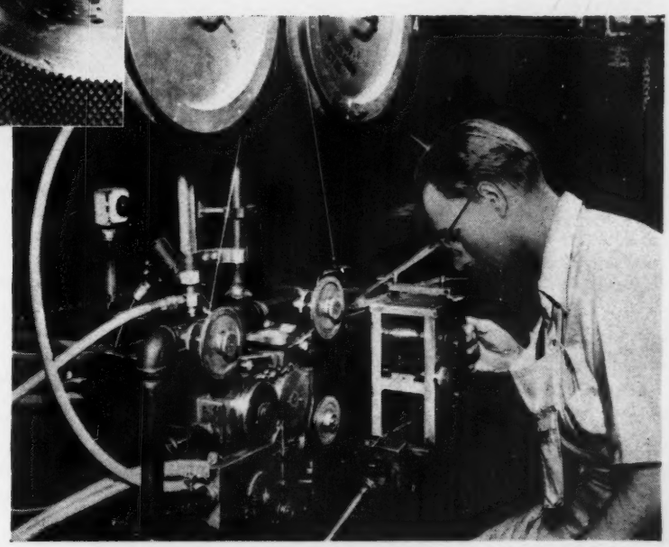
NUMBER 9 OF A SERIES

Newsworthy Notes for Engineers



Winding wire on a "wedding ring"

This is the "Sea Breeze," a machine developed by Western Electric engineers. It solves the problem of winding wire half the thickness of a human hair on a toroidal core the size of a wedding ring. Compressed air drives the flyer which maintains the wire under positive tension at all times, winding as many as 40,000 turns of #46 wire on the core. It winds finer wire than any previous machine, lays turns more uniformly, winds a wider range of wire sizes, increases efficiency in utilization of winding space and permits the manufacture of coils half the size of those previously possible.



Metal welding that saves millions

Here, palladium and nickel tape are welded together at the rate of 400 feet an hour. Tiny bars are later snipped from this bi-metal tape and used to replace the precious pinhead-size platinum rivets once used as contacts in Bell System relays. These contacts, which minimize noise in telephone conversation, are used by the billions in relays that perform switching operations. The use of this bi-metal tape... devised by Bell Telephone Laboratories scientists and produced on machines developed by Western Electric engineers ... saves millions of dollars a year in the cost of producing telephone equipment.

Engineering problems *are many and varied at Western Electric, where manufacturing telephone and radio apparatus for the Bell System is the primary job. Engineers of many kinds—electrical, mechanical, industrial, chemical, metallurgical—are constantly working to devise and improve machines and processes for mass production of highest quality communications equipment.*

Western Electric

A UNIT OF THE BELL SYSTEM SINCE 1882

"Okonite leadership is a matter of engineering background"

AN OKONITE "TWIST" ON CABLE TESTING

Okonite research includes subjecting short lengths of electrical cable to torsion tests (pictured above), twisting them through a spiral arc of 180° under a heavy load.

Bending tests, impact tests, tests of wear-resistance by abrasion — these are a few of the mechanical tests which, along with electrical, chemical and weather-exposure tests, complete an integrated program of performance checks. From its results comes information which Okonite engineers translate again and again into wire and cable improvements that mark major advances in the field. The Okonite Company, Passaic, New Jersey.

5171

OKONITE SINCE 1878

insulated wires and cables

BEHIND IT...A *LITTELL REEL*

Engineers are aware of the tremendous mechanical problems involved in the manufacture of even such a commonplace thing as the telephone. "Behind" many of its intricate parts, you will find a *Littell Reel,* efficiently playing its part in helping provide accurate, economical stampings.

LITTELL

F. J. LITTELL MACHINE CO.

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GERMANY — 1947

(*Continued from page 162*)

structure. After an examination of the plans it becomes apparent that the design is not sound. One test beam has already been constructed according to the plans, and we proceed to subject this beam to a test load. When the weight placed on the beam reaches fourteen per cent of the designed load, the beam fails. Since it is essential to finish the building as rapidly as possible, a new design has to be secured at once. I therefore decide to call my home office in Frankfurt and take up the matter with our designers. I explain the situation,

A wooden roof truss in the Dachau Camp which failed under fourteen per cent of its capacity load

Werner H. Gumpertz

giving them all necessary data and measurements. The chief designer asks me to call him back within twenty minutes. When I call for the second time, he has made a complete design of a new timber truss, and gives me all measurements over the telephone. I make a sketch of the new telephone-transmitted design and hand it to Mr. Schlenker. Construction of the new truss is started the same day and completed without further incidents. Now I take the opportunity to inspect the new water supply line. Construction of this line has been held up by the lack of a few hundred feet of concrete pipe. A routine inspection of all engineering work and facilities follows and a number of minor details are taken up before I prepare the final report on my inspection of Camp Dachau.

While writing my report in the afternoon, I suddenly remember that this is Saturday. Civil engineers in Europe, too, have free week-ends. The report will have to wait until Monday. I climb into my faithful jeep again and, a few hours later, arrive in the famous winter resort of Garmisch, the scene of the 1936 Olympic winter games. A cogwheel mountain railroad takes me to the top of the Zugspitze, the highest peak in the German Alps. After approaching the foot of the mountain, the train enters a tunnel and winds its way to the top without once coming into the open. The terminal is located somewhat below the peak, and the summit is reached by cable car. The view from there is very impressive, and includes a great part of the Austrian as well as the German Alps. Back in the valley, winter sports, entertainment and breakfast in bed make me forget that I am quartered in an Army hotel.

On Monday morning I arrive at the European Theater Intelligence School. I find that the post engi-

(*Continued on page 166*)

Kodak

Because photography authenticates...

Show a jury photographic evidence . . . they're pretty sure to recognize its authenticity. The camera, they know, records exactly what it "sees"—no more, no less . . . reports impersonally, without prejudice.

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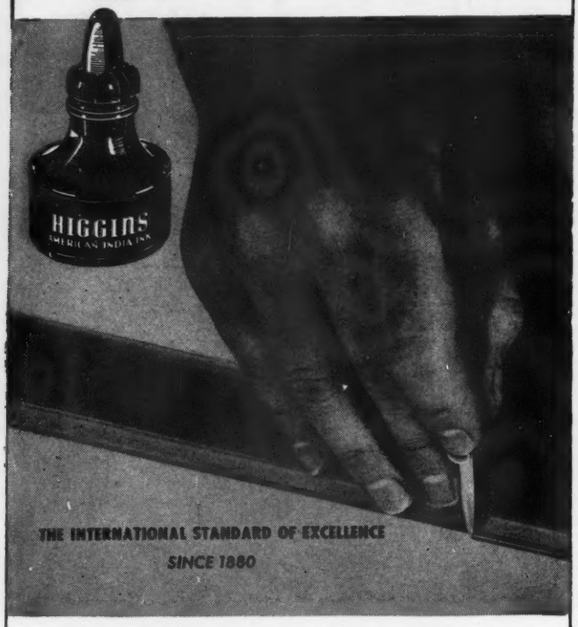
Lay it on the line



You'll always win

HIGGINS INK CO., INC. 271 NINTH STREET, BROOKLYN 15, N. Y.

GERMANY — 1947

(*Continued from page 164*)

neer is an old friend of mine, who soon proceeds to tell me of his many woes. Like most local engineers, he complains that his post is neglected by the "Chief's office." He cannot get hardwood flooring for the gym, nor enough draperies for improving the acoustics of the movie theater. No special engineering problems develop, and the discussion centers mainly around maintenance supplies. I do my best to explain the overall supply situation and to prove that this post is not being unduly neglected.

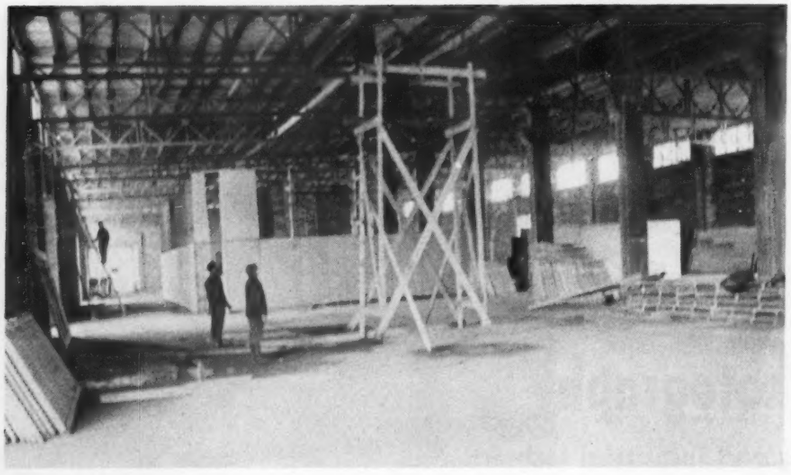
When I leave Oberammergau, my mission is completed. While driving back to Frankfurt, I think about many other trips I have made in the past. There is the Engineer depot in Hanau, where Bailey bridge panels are used as roof trusses in the big warehouses. In Wuppertal near Cologne, there is the famous "floating trolley," which is suspended from a steel structure above the streets and the Wupper River and serves as a rapid transit railroad traversing the length of the whole city. Then there are the Rhine River bridges destroyed during the war. Rotterdam, devastated during the "Blitz" in 1940 by the Germans is still a sad sight. Switzerland is a fascinating country for an engineer with its many bridges and mountain roads. The famous double track Gotthard railroad crosses the Alps on many bridges and tunnels to connect Central Europe with Italy and the Mediterranean. I had the opportunity of visiting my old alma mater, the Swiss Federal Institute of Technology in Zurich. Trips to Holland, Belgium, Luxembourg and France gave further opportunities to study a multitude of civil engineering structures.

I am sure that some of my readers are interested in the professional aspects of working with the Army overseas, and where the young engineer fits into the picture. Surroundings as well as working conditions are quite different from what one expects to find in this country. I will therefore mention some of the problems that I have encountered while in Germany as a structural engineer.

A resident engineer is usually in charge of a detachment of Army Engineers. The actual work is carried out by German labor employed directly or by local contractors. American enlisted men serve as construction supervisors, truck drivers and operators of the United States Army construction equipment. The representative of the Office of the Chief Engineer acts as inspector and technical advisor. Since he is acquainted with a great variety of construction projects, he has opportunity to judge and compare methods and problems, to be familiar with the supply situation in the different regions of the American zone and to apply this knowledge advantageously to the project visited. After a while he also grows familiar with the various personalities engaged in construction activities all over the zone and can sometimes straighten out personal and administrative difficulties between the people concerned. Finally, he is the "watchdog" of the organization, charged with the great responsibility of seeing that all public funds are used economically and efficiently without undue help to local interests. During my inspections I had numerous opportunities to stop certain phases of work that were not in the interest of the occupation, but desired by high-pressure native groups. Sometimes I could also be of help in obtaining indigenous labor in areas of labor shortage and in acting as liaison agent with local government agencies.

The interior of one of the large warehouses in Hanau, showing the Bailey Bridge panels used as roof trusses. The rest of the building is of reinforced concrete frame with concrete block walls

Office of Chief Engineer, Construction Division, Frankfurt



(*Continued on page 168*)

GAS.. PRODUCTION-LINE FUEL

Homestead Lever-Seald Valve—for handling fluids at high pressures and temperatures—one of the multitude of Homestead Valves for all types of applications.

Gas-fired "SKLENAR" Furnace for high-speed melting of ferrous metals.

Sectional Gas-fired core-drying oven.

for FOUNDRY MODERNIZATION

Foundry modernization is a continuing project at Homestead Valve Manufacturing Company, Inc., Coraopolis, Pa., because Homestead engineers have since 1892 kept their sights set on modern productioneering equipment and methods.

And, in their research, these engineers have investigated fuels and combustion techniques as they apply to foundry practice. As a result the productive flames of GAS are increasingly important and more extensively used in Homestead's production lines.

Modern Gas-fired Foundry Equipment, such as the "SKLENAR" furnaces for ferrous metal-melting, utilize the special characteristics of GAS—flexibility, controllability, speed. This saves equipment space, melting time, and lining maintenance. Operating at 2700° F. these furnaces have a capacity of one ton heat per hour, and 160 heats per lining—evidence that modern Gas Equipment is really productioneering equipment.

But this is not the only GAS application in the manufacture of Homestead valves. Core ovens, annealing furnaces, and non-ferrous crucible furnaces are all heated by the productive flames of GAS. In modern foundry practice GAS is the logical fuel for all heating and heat-treating operations.

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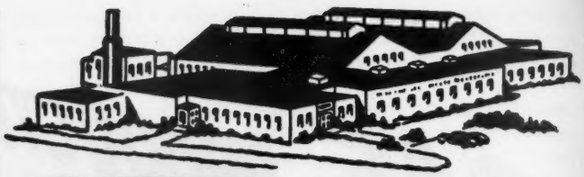
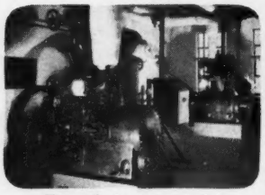


Part of the Poultry Processing Line

Frozen Chickens in -5° Storage



Two of the Four Frick Compressors

Processing 24,000 Chickens Daily with

FRICK Refrigeration

They do it in the new plant of the Southern States Eastern Shore Marketing Cooperative, at Salisbury, Md. • Here 56,000 birds are kept on hand; the entire daily pack is cooled to 35°F, and half the chickens are quick-frozen at minus 35°. One of the storages is kept at 32°, the other at minus 5°; each holds 200,000 lb. of poultry. Up to 25 tons of ice are made per day, for precooling and shipping purposes. • Frick Refrigeration handles all the cooling work. If you want to be "in the know" on the latest quick-freezing methods, write for Frick Bulletin 147-B.

DEPENDABLE REFRIGERATION SINCE 1853
FRICK CO
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GERMANY — 1947

(*Continued from page 166*)

Very few graduate American engineers are available to do designing and to act as construction supervisors. Most Army engineer officers are also bogged down in an amazing amount of red tape and general military duties. As a result the young engineer is often given responsibilities far beyond his age and corresponding experience. Consequently he will have the valuable opportunity to prove that he is able to discharge his duties efficiently, while he might be assigned to minor or routine tasks when working in this country. As a rule the trust put in these young engineers has been entirely justified, and a great number of successfully completed contruction projects bear testimony to that fact.

Some of the disadvantages should also be pointed out. Work overseas is performed in a certain isolation, since there is no opportunity to meet with members of the great domestic engineering and construction firms. A prolonged stay overseas would therefore cause the young engineer to lose contact with conditions in this country. There are some basic differences in engineering conceptions between present-day Germany and the United States. While financial considerations here are tantamount, requiring the most efficient machinery and economy in the use of labor, the goal in Germany is to spread the small amount of material available as far as possible, even if this means the waste of time and skilled labor. Improvisations, unprepared changes and unorthodox methods are often required and successful when the same course of action in this country would mean the economic failure of the project concerned.

There is of course frequent contact with German engineers on whom the Army engineers often have to rely heavily. Some of these people have good training, but they are set in their ways and believe in doing a thing "just so" because they have always done it that way. Politically and morally very many of them are unreliable and time and again will try to use the Americans for their own purposes. Some of them actually have the attitude — carefully concealed — "why should we superior people work, if we can make those American suckers do it?" Some designers working in American offices with little supervision have turned out inadequate designs resulting in the failure of structures — a case of gross neglect, incompetence or a subtle form of passive sabotage. Unless closely checked, the Germans might give an amazing amount of misinformation about all phases of the work.

To sum it all up, it has been an interesting time and I have gained valuable experience. But I realize how much human misery has been necessary before it was possible to occupy Germany. I only hope that we will do a good job now to remove the constant menace of war from our lives.

NUCLEAR POWER

In the March

T · E · N

Watch for it!

This girl can beat 50 monks to a standstill

Nowhere in the world are elevators as luxurious—efficient—and safe—as in America. Nowhere are such ingenious improvements made so consistently . . . so rapidly.

The ancestor of elevators—a crude basket attached to the end of frayed rope—*still* is in daily use—the only access to some monasteries in Greece. Powered by monks, fifty of whom could not do what a little slip of a girl does with one hand, these "elevators" try the nerves of brave men.

American ingenuity, born of individual enterprise, and nurtured by free competition, not only gave us the world's best elevators, it gave us a great industry employing thousands of men and using the products of a score of other industries.

The wire rope industry is not among the least of these.

Roebling engineers have kept pace with the designers of "lifts" ever since the first American elevator was installed with a Roebling elevator rope —back in the early 1860's.

Today, Roebling Special Traction Steel Elevator Rope enjoys the well-earned confidence of hoisting engineers the world over.

JOHN A. ROEBLING'S SONS COMPANY
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NEW-FOUND FORMS

(*Continued from page 147*)

for if an interior could be logically arranged in a rectangular plan, and if buildings need not conform to the ground, then a *simple* exterior could be achieved. Corbusier restrained façades to a play of rectangles, and reduced buildings to box-like simplicity, a far cry from Rococo and Victorian "gingerbread." It was Purism — a return to the geometric patterns that Plato loved so well. Corbusier's buildings are complete in themselves — unrelated to the earth, even to the point of having gardens on the roofs.

Diametrically opposed to Le Corbusier is Frank Lloyd Wright, an architect who was inspired by Nature, and felt that people are not close enough to it. Unlike Corbusier, Wright designs buildings to fit the ground; to get closer to earth by stressing horizontal lines; to bring the "outside in and the inside out"; living terraces are put outdoors. Local stone and wood further integrate building with earth. Wright fulfills John Ruskin's plea, again of 1840, for an "architecture of nations as it is influenced by their feelings and manners, as it is connected with the scenery in which it is found and with the skies under which it was erected." As one walks freely through the woods, so can one freely travel through the house, for it is no longer divided into rooms — the plan is freed from convention; walls are arranged to give that sense of spaciousness so typical of Wright's buildings. Construction is not paper-thin as in Le Corbusier's buildings, but is massive. Since the floor plan is related to the ground, the buildings lie casually on the earth. Nothing is forced into box-like shape, rather is each interior space recognizable on the exterior as a separate volume. Richness of composition results.

Le Corbusier has severed with tradition, whereas Wright's structures show steady evolution to a new style where classical *principles* are still retained — proportion; repetition of a building element; dominance of the building by an entrance, a dome, or veranda; and evolution from one end of a building to a point of climax, which would be the dominant feature. Symmetry is superceded by balance. Decoration is once again a creative, not an imitative, art. Materials are chosen not only for their functional purpose, but for the way they harmonize with each other and to the environment. As a result there is no prototype structure, but a regionalized architecture. A house on the desert seems to belong on the desert, and a house nestled among green hills seems to belong there. There is contrast of colors, contrast of emphasis of direction, and counterplay of light and shade.

It is one thing to look at a building and another thing to walk through it. Wright recognizes this fact by relating walls, windows, and ceilings to the motion of a person, so that pleasant sensations are aroused as one moves from an area of semi-darkness to a light area, or from a low level to a higher level. A new vista confronts one at every turn.

But there must be something in common between Corbusier and Wright. There is. Both men believe that structure is not to be hidden. Columns are regarded as elements of beauty. But the manner in which these columns are arranged and designed creates different effects in each case.

The most revealing difference between Wright and Corbusier lies in their theory of city planning. Corbusier thinks in terms of large housing projects with identical apartment houses arranged in systematic order. He is the champion of urbanism, the proponent of efficient living as a function of orderly planning. His buildings are the very essence of the simple and efficient life; they are a manifestation of regimentation.

Frank Lloyd Wright's conception of planning is one of town and country blended together, with an occasional dwelling unit, surrounded by smaller units. It is the idea of a life that is enriched by variety of experiences. He is against any unnecessary regulation over planning and design, for that would destroy the creativeness that comes with individual inspiration. His buildings, whether they are costly or economical, are for those who would live luxuriously.

It is significant that the greatest influence of Corbusier on other architects is in the design of public buildings (it is obvious in the design of the United Nations Center in New York, for which he is one of the architects), whereas Wright's greatest influence has been on the design of the house — the domain of the individual.

Other Leaders

Walter Gropius, now in our country as head of the Harvard School of Architecture, believes, much the same as Corbusier, that the plan should be subjugated to the simplest perimeter, where it is practical, for the sake of economy. He also prefers a scheme of black and white to a color scheme, and believes that variety in a plane is preferable to variety of form.

Mies van der Rohe, now head of the Department of Architecture at the Illinois Institute of Technology, believes in precision of construction and good craftsmanship as essential features of good architecture, whereas Wright employs local craftsmen, who are familiar with the local materials that he uses. Van der Rohe is noted for the freedom of plan he achieves within a simple, rectangular building.

William Wilson Wurster, Dean of M. I. T.'s department of architecture, also believes in using local materials, rather than the exotic metals and stones that van der Rohe likes to use. Dean Wurster feels that we should not impose the buildings of our age on succeeding generations, for whom they will be outmoded, but that we should build for the present generation. His buildings, predominantly houses in California, are adapted to the landscape, with facilities provided for maximum outside-inside living.

There are many architects who specialize in designing "modern" homes that have utmost heating efficiency, ideal orientation, and any of the other advances of modern science. Many use the new "tools" of modern architecture in the most efficient manner, without much philosophy of design, in the belief that an element if used functionally will, by necessity, be pleasing.

The Conflicts

Contemporary architecture is composed of modern architecture and eclectic architecture. In modern architecture there is no *one* trend; in contemporary architecture there is a steady trend toward modern. As more modern is built, people realize that what they once thought was the modern is actually only one phase of modern. They realize they have a choice between Corbusier, Wright, or an "in-between."

Modern architecture has the potentialities of a great architecture. The machine age presented new problems to architecture; it was modern architecture that showed they could be solved by new structural concepts. It has shown that it can so arrange its new structural elements to be intensely expressive of two antitheses, collectivism and individualism, which are the struggles of our modern world. The outcome and future trends of architecture will depend on the philosophical, religious, political, and economic struggles that exist today.

"Our American concept of radio is that it is of the people and for the people."

Freedom to LISTEN – Freedom to LOOK

As the world grows smaller, the question of international communications and world understanding grows larger. The most important phase of this problem is *Freedom to Listen* and *Freedom to Look*—for all peoples of the world.

Radio, by its very nature, is a medium of mass communication; it is a carrier of intelligence. It delivers ideas with an impact that is powerful . . . Its essence is freedom—liberty of thought and of speech.

Radio should make a prisoner of no man and it should make no man its slave. No one should be forced to listen and no one compelled to refrain from listening. Always and everywhere, it should be the prerogative of every listener to turn his receiver on or off, of his own free will.

The principle of *Freedom to Listen* should be established for all peoples without restriction or fear. This is as important as *Freedom of Speech* and *Freedom of the Press.*

Television is on the way and moving steadily forward. Television fires the imagination, and the day is foreseen when we shall look around the earth from city to city, and nation to nation, as easily as we now listen to global broadcasts. Therefore, *Freedom to Look* is as important as *Freedom to Listen,* for the combination of these will be the radio of the future.

The "Voice of Peace" must speak around this planet and be heard by all people everywhere, no matter what their race, or creed, or political philosophies.*

David Sarnoff

President and Chairman of the Board,
Radio Corporation of America.

**Excerpts from an address before the United States National Commission for UNESCO.*

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HARMONY

(*Continued from page 150*)

the first interval in the scale. Also, another note is needed approximately midway between f and g, which we shall call f♯.

Similarly, as we modulate upward through another fifth to the key of D, two more notes are needed: one, a little above e, and the other, c♯, between c and d. Continuing to modulate upward through fifths, and adding the required notes to the scale, we pass through the keys of A, E, B, and into the keys of our newly created notes, F♯, C♯, G♯, D♯, A♯, E♯, and B♯. This can be continued indefinitely without ever returning to the original key or repeating any key.

Similarly, modulating downward by fifths from the key of C brings us first to the key of F, whose scale requires the introduction of two new notes; one slightly above d, and the other (b♭) between b and a. Modulating downward we pass through the keys of F, B♭, E♭, A♭, D♭, G♭, C♭, etc., again a process which can be continued indefinitely.

Now it is desirable to have a system which, after a certain number of modulations, will return to the original key, so that any number of modulations may be performed using a finite system of notes. This is quite necessary, as many of our instruments are so constructed that they can produce only a certain number of discrete notes. The voice, the viols, the slide trombone, and a few others are capable of continuous variation of pitch, but many (especially the keyboard instruments, such as piano and organ) are not. If such instruments were equipped to play the above perfect scales in several keys, they would be exceedingly complex and difficult to play. Therefore, it has become necessary to modify the scale from the perfect ratios described above to something which approximates it but is capable of being played in several keys by one instrument.

It is found that proceeding upward through the four fifths

c — g — d — a — e

gives us an e which is slightly sharp when compared to the e a major third above c. The difference between the two thirds thus formed is defined as a *comma*, an interval whose ratio is easily computed to be 81/80. If all the above fifths are flattened a quarter of a comma, the e produced by proceding upward through four fifths will coincide exactly with the e a perfect major third above c. This was the basis of the *mean-tone* system. This system allowed some modulation without unduly complicating the keyboard, but this was accomplished at the expense of using fifths which were not perfect. The keyboard used with this system was generally similar to ours, having twelve keys. Using this system, there was always one fifth which was extremely bad, as twelve of these flat fifths constructed as above do not equal an integral number of octaves. This meant that music written in certain keys sounded bad, as some of the chords contained notes on opposite sides of this bad fifth. This effect was known as the "wolf."

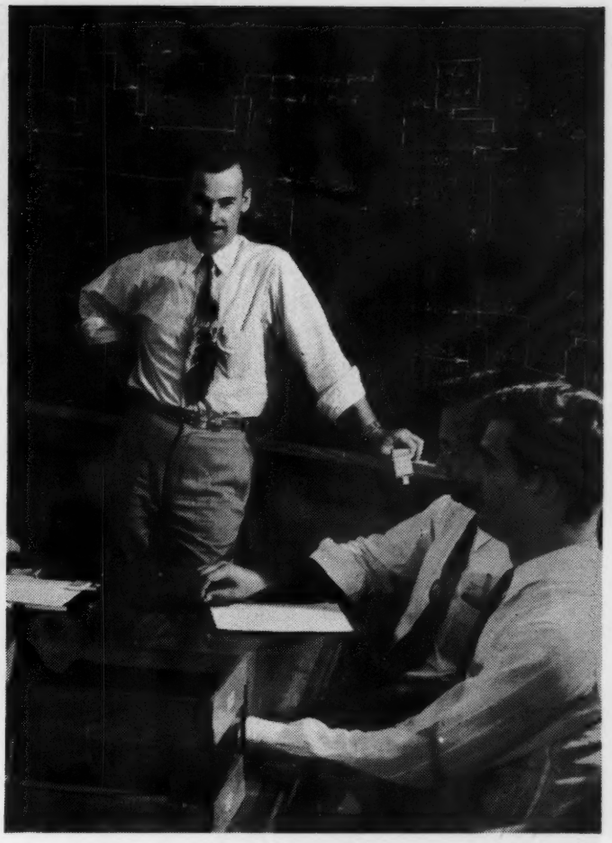
While a few organs tuned to this system still exist, most instruments are now tuned to a system in which the octave is divided into twelve equal semitones (each of ratio $\sqrt[12]{2}$, as ascending through twelve of them doubles the frequency). In this system the same chords in all twelve keys have the same intervals, and modulation brings one eventually back to the original key, as shown in the diagram, figure 4, which is often called the circle of keys. Modulation upward by fifths is represented by proceeding clockwise around the circle, while modulation downward is represented by proceeding counter-clockwise. In this *equal temperament* system, as it is called, there is no distinction made between the sharp of a note and the flat of the note a whole tone above, as all semitones are equal.

Mechanically, this system sounds like a satisfactory solution, but does it sound good? Shown graphically in figure 5 are the perfect, or true major scale, the Pythagorean scale, and the E. T. (equal temperament) major scale of the key of C. It is seen that fifths played on the E. T. scale are slightly flat, and major thirds are considerably sharp. Only octaves are perfect. It is said that harmony did not develop under the Pythagorean scale because the intervals were so far from those of the perfect scale. Our scale is not very much better in some of the intervals. It differs enough from the perfect scale so that some musicians dislike music played on instruments tuned to it. (This includes virtually all keyboard instruments now in use, plus many other instruments.) There have been instances in which

(*Continued on page 174*)

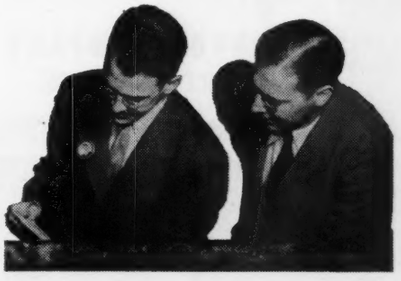
SALLY CHERRY, one of the laboratory experts who keep Esso Products high in quality.

JOHN BRITTON, Esso Heating Oil Clerk makes up delivery schedules from card index of customer needs.



W. D. BEISNER, University of Minnesota '46, **C. T. STEELE,** University of Missouri '38, **R. S. PENDEXTER,** V. P. I. '41, confer on trouble phases of refinery operation.

Good PEOPLE are Good BUSINESS!



WILBUR HUNT, Pittsburgh '42 and **D. F. EATON,** Iowa State '34 discuss Wax Plant operations.

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LABELING MACHINES (BEHR-MANNING DIVISION: COATED ABRASIVES AND SHARPENING STONES)

HARMONY

(*Continued from page 172*)

singers who sing both with accompaniment and *a capella* have had difficulty adjusting themselves to the equal temperament. When singing alone, it is natural to use the perfect scale. When accompanied, the singer must follow the scale of the accompanying instrument, whatever that may be.

We have no practical solution to this problem. Many musicians hold that the development of a system of perfect (or nearly perfect) scales with the technical advantages of the equal temperament scale would improve musical harmony considerably. It is to be hoped that an answer will be found.

NEW YORK TO BOSTON

(*Continued from page 154*)

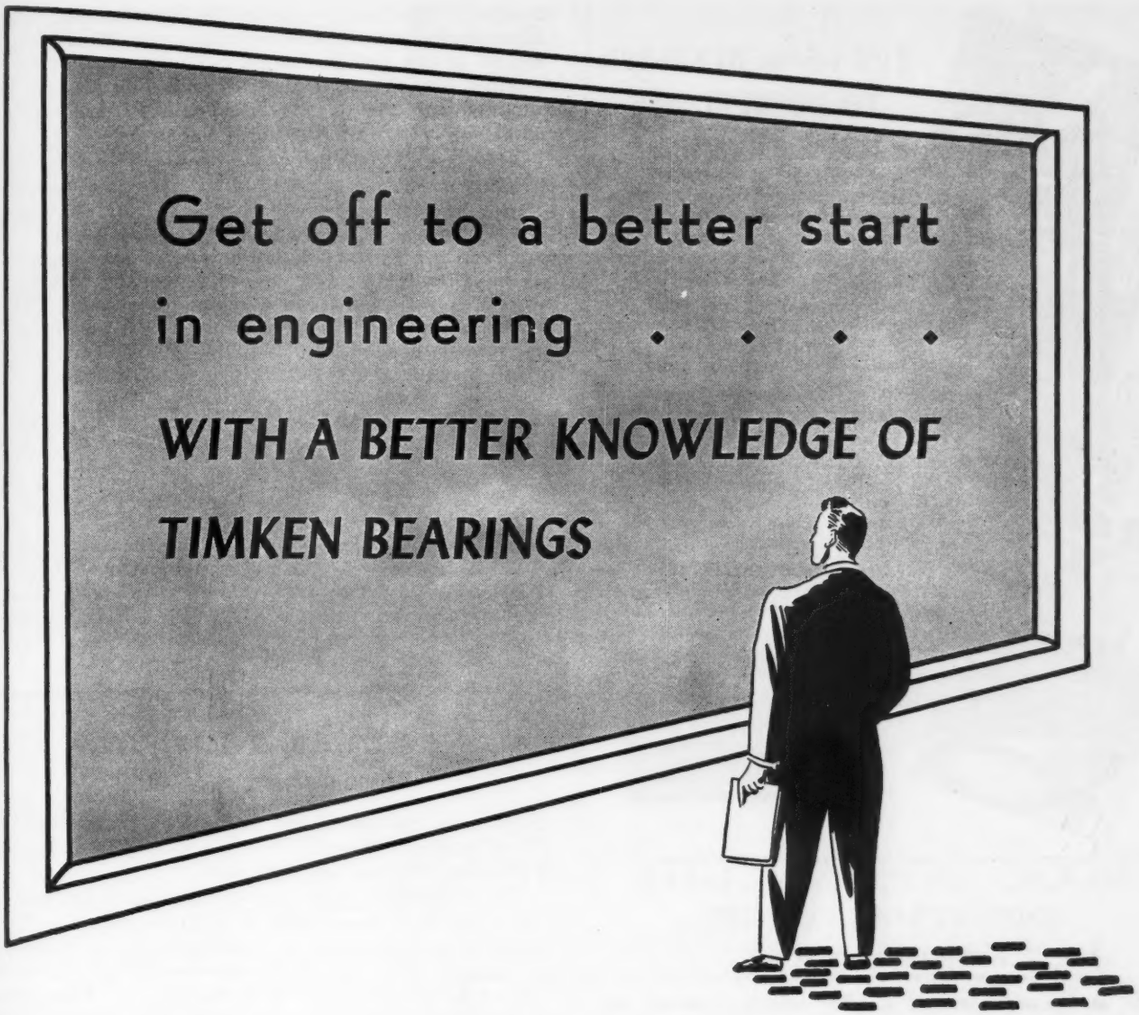
and, in conjunction with carrier equipment, large numbers of telephone or teletype messages.

At the present time, coaxial cable is being used to a far greater extent than microwave systems, as the map in Figure 1 indicates. The New York-Boston link is the first permanent radio relay system to be installed, though others have been installed for temporary service over short distances, using equipment developed during the war for the army. A radio relay system between New York and Chicago is being planned and is expected to be completed in 1949. Meanwhile, the expansion of coaxial cable facilities is going forward. By 1950, a total of 12,000 miles of coaxial cable will be installed.

It is not yet known whether coaxial cable or the radio relay system will prove to be economically superior. The New York-Boston radio link will help to answer this question. Present indications are that both systems will eventually be used, the choice of one or the other being determined by particular traffic needs and particular geographical conditions.

Radio relay systems use the very top range of the radio frequency spectrum (3000 – 12,000 megacycles) because radio energy transmitted in this frequency range can be concentrated into very sharp beams by means of directional antennas. Such sharply focused beams give very clear and dependable reception. In general, the higher the frequency, the greater the directivity. Below 3000

(*Continued on page 176*)



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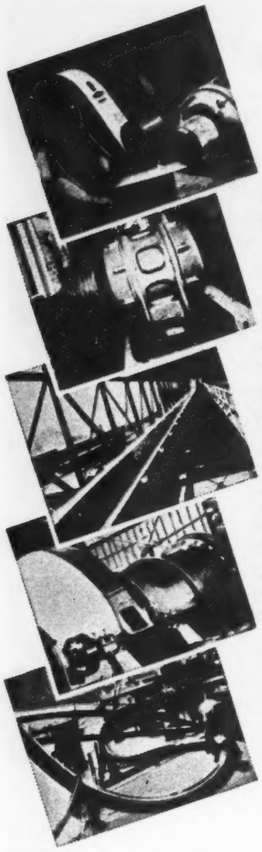

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THERMOID COMPANY, TRENTON, N. J., U. S. A.

INDUSTRIAL OXYGEN

(*Continued from page 153*)

the air passes through a filter which removes suspended particles. Next, the air enters a reversing exchanger which brings the temperature of the air down quickly.

From the reversing exchanger the air passes into the expansion engine. The pressure of the gas entering the engine and leaving the engine is regulated by two surge chambers. These are tanks which are mounted on either side of the engine and help store the air between cycles of the engine. From the engine the air passes through another heat interchanger which is composed of three concentric tubes like the reversing exchanger. However, since all the impurities have been removed, the reversing mechanism is unnecessary.

The air now enters a tube which passes through the bottom of the distilling column. Since previously-generated liquid oxygen is present in the bottom of the still at the much lower pressure of six pounds per square inch, the oxygen absorbs heat from the air and boils while the compressed air condenses. The liquid air passes into a third interchanger in counterflow with the waste nitrogen which is at a lower temperature. Finally, the liquid air flows through a constricted tube into the top of the still, trickles downward over the packing in the still, and absorbs oxygen from the vapor stream rising from the bottom. At the same time the vapor stream absorbs nitrogen from the liquid stream so that it is greatly enriched in nitrogen by the time it reaches the top of the still. The liquid stream has lost all its nitrogen by the time it reaches the bottom. Both the oxygen and waste nitrogen are conducted directly from the still to the heat exchange mechanisms previously described and thence to the exterior. The nitrogen is discarded and the oxygen is brought to the oxygen compressor which compresses it for storage.

This carefully worked-out process provides for the preservation of as much cold in the system as possible in order that the device can operate at peak efficiency. By using the reversing exchanger and the flexible rod expansion engine, the pressure for operation at capacity has been reduced to 150 pounds per square inch in a very small plant, much lower still in a large plant. The number and size of parts has been reduced so that the unit may be carried aloft in aircraft. The only cost of actual operation is the cost of compression, since all chemicals and expended materials have been eliminated from the process. This new, low pressure, oxygen generator developed at M. I. T. will probably make industrial oxygen available for use whenever needed since the inefficiency, cost, and bulkiness of the generator have been eliminated.

The flexible-rod expansion engine has been used with much success in the recently-developed helium cryostat or refrigerator which provides an experimental chamber at a temperature only a few degrees above absolute zero.

NEW YORK TO BOSTON

(*Continued from page 174*)

megacycles, the directivity is insufficient for this sort of application. Above 12,000 megacycles, the radiation is absorbed by rain, fog, and snow.

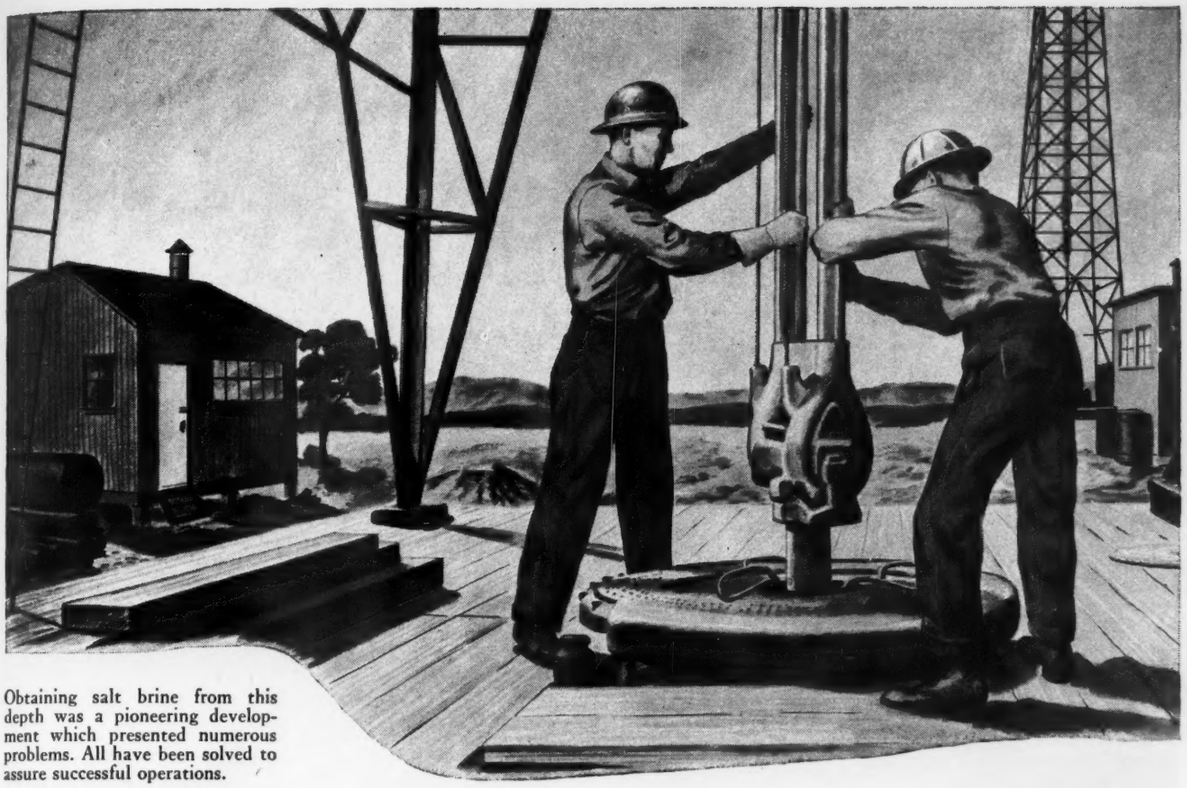
The frequency range used on the New York-Boston relay system is from 3930 to 4170 megacycles. The antennas used to direct the radio beams are illustrated in Figure 2. They are 10 feet square and use the wave guide principle to obtain their directivity. They have a directivity of 38 db over a dipole, which means that a dipole would have to radiate 40 million times as much power as the transmitting antennas to obtain the same signal strength at the receiving station.

Wave guides carry the radio waves between the antennas and the transmitters and receivers. These wave guides are filled with nitrogen and are kept at 10 psig to prevent the influx of moisture, with consequent corrosion.

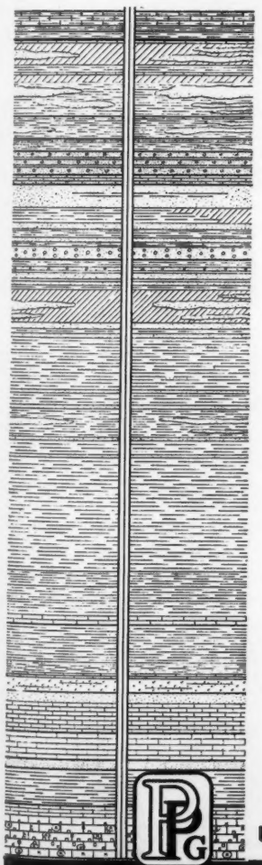
The output of the transmitters used in the system is from .5 to 1.0 watt. The carrier is frequency modulated, with a frequency deviation of ± 2 megacycles. The receivers use a superheterodyne circuit with an intermediate frequency of 65 megacycles.

There are seven relay stations in the system, located as shown in Figure 3. These stations are all located on high hills; since, due to the directivity of the radiation, it is necessary to have a direct line of sight between stations. At each relay station, signals are received from both directions; and the output of the receivers is used to modulate transmitters which re-transmit the signals, greatly strengthened, to the adjacent stations.

The relay stations receive their power supply from commercial power lines; but in case this source of power should fail, auxiliary batteries and gasoline-driven generators would take over automatically. There are no attendants at the relay stations; their operation is entirely automatic.



Obtaining salt brine from this depth was a pioneering development which presented numerous problems. All have been solved to assure successful operations.



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The favorable location of the Natrium plant was established as a result of pre-Pearl Harbor studies by Columbia. Built and operated for the DPC, its post-war purchase by Columbia assured continued operation so helpful in meeting the urgent needs of industry for caustic and chlorine. The caustic soda is purified by a patented Columbia process to meet exacting uses such as required in the manufacture of rayon.

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DU PONT Digest
For Students of Science and Engineering

Weaving of nylon yarn required the development of special sizing material

Problem solved by Du Pont men with many types of training

Each new product that is created in the laboratory seems to bring with it a new set of problems to challenge the ingenuity of the scientist. An outstanding instance of this is nylon. To make practicable the weaving of nylon into textiles, it was necessary to develop an entirely new slasher sizing material —a coating to make the filaments adhere to one another, protect the yarn from abrasion and keep it clean. Sizes used on other fibers proved unsatisfactory on nylon, because of its unique chemical composition.

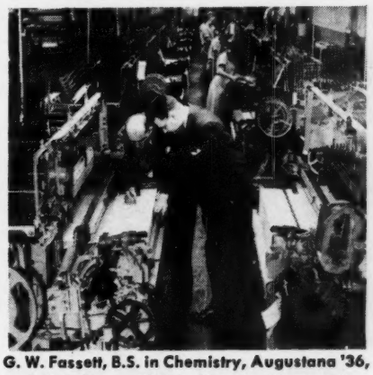
Five candidates were exhaustively tested by Du Pont men. Best by far proved to be polymethacrylic acid (PMA), $[CH_2=C(CH_3)COOH]_x$, possibly because its acidic nature is favorable to hydrogen bonding with the polyamide structure of nylon.

Many technical problems involved

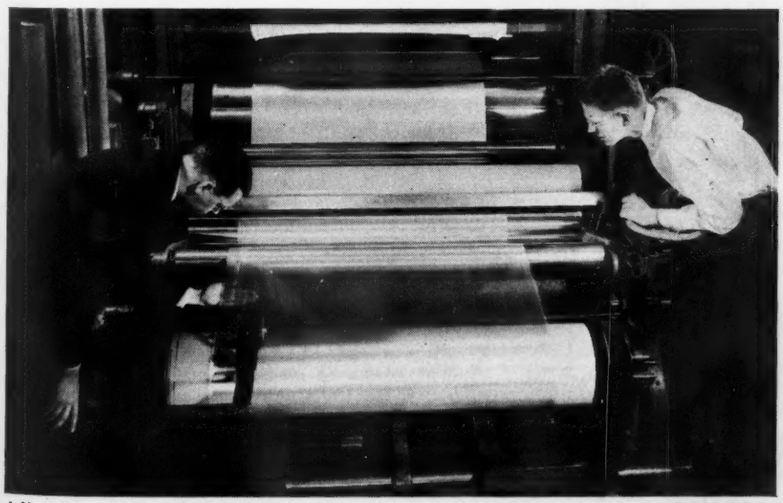
(1) After weaving, sizing has to be removed by water. PMA dissolves in water readily up to 10% at room temperatures, but precipitates between 70-80° C. A way had to be found to prevent precipitation at the normal scouring temperature of 100° C.

(2) PMA sets to a brittle, glassy material on fibers, giving a harsh wrap. Suitable plasticizers such as sulfonated vegetable and mineral oils, glycols and other polyhydric alcohols had to be found to correct this condition and permit stretching and flexing of the yarn without film impairment.

(3) Good dispersing agents were necessary so that the powdered PMA would not agglomerate as it dissolved in the sizing bath.



G. W. Fassett, B.S. in Chemistry, Augustana '36, and W. A. Franta, M.S. in Chemical Engineering, North Dakota '34, inspect woven fabric made from PMA sized nylon warp in Du Pont Experimental Weaving Laboratory.



J. M. Griffing, Ph.D. (Organic), Columbia '45, and A. Deschoemaeker, B.S. in Chemical Engineering, Lehigh '41, inspect PMA size solution and check nylon warp at head end of a slasher. In slasher sizing, entire warp is coated rather than a single thread.

(4) Optimum concentrations of PMA and the various plasticizers had to be determined, and application temperatures worked out for the different types of fabrics (satins, twills, taffetas, etc.) to be sized.

The basic reactions involved in making methacrylic acid monomer are straightforward:

$$\underset{\text{(acetone)}}{(CH_3)_2CO} + HCN \longrightarrow \underset{\text{(acetone cyanohydrin)}}{(CH_3)_2C(OH)CN}$$

$$(CH_3)_2C(OH)CN + H_2O, H_2SO_4 \longrightarrow \underset{\text{(methacrylic acid monomer)}}{H_2C=C(CH_3)COOH}$$

But several technical difficulties in the manufacture of the polymer had to be overcome:

(1) The distillation of the monomer has to be controlled carefully to keep it from polymerizing in the still head.

(2) The monomer must be obtained free of any color-forming impurities that might cause permanent discoloration of the fabric by the final polymer solution.

(3) Polymerization of the monomer must be carefully regulated to get reproducible results and constant molecular weight. This is important because the molecular weight of the PMA determines the viscosity of the size.

(4) Drying the polymer presented unusual difficulties. A special study was made to find an economical drying process that would give a uniform, finely divided product adapted to rapid solution.

Credit for the development of PMA textile sizing, is shared by Du Pont men with many types of training—chemists, physicists, chemical engineers and textile experts, as well as the technical service men who worked in close cooperation with leading textile manufacturers during commercial trials.

Questions College Men ask about working with Du Pont

Where would my job be?

Openings for technical graduates may exist in any one of the 38 Du Pont research laboratories or 85 manufacturing plants. Every effort is made to place men in positions for which they are best suited and in the section of the country which they prefer. Write for booklet, "The Du Pont Company and the College Graduate," 2521-B Nemours Building, Wilmington 98, Delaware.

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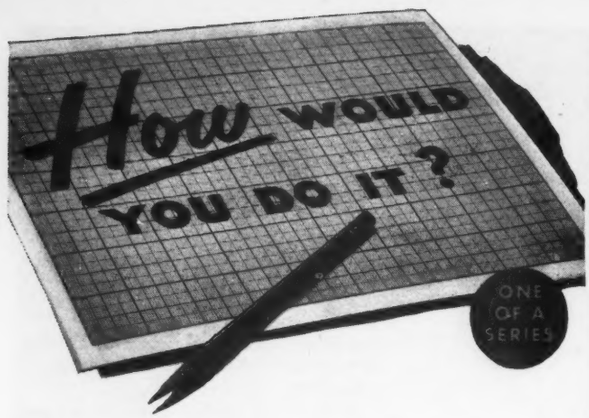
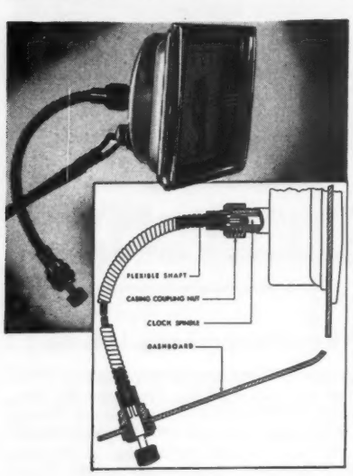
...THROUGH CHEMISTRY

More facts about Du Pont — Listen to "Cavalcade of America," Mondays, 8 P.M., EST on NBC



PROBLEM—You are designing an electric clock for automobiles. The clock itself is completed. To set the clock, the spindle which turns the hands must be pushed in against a spring pressure and then turned—and, of course, when the clock is installed, this spindle is back under the dashboard. You want to provide a means for pushing and turning the spindle from a point that is easy to get at. How would you do it?

THE SIMPLE ANSWER—Use an S.S.White flexible shaft. The illustrations show how one manufacturer does it. Regardless of where the clock is mounted, the flexible shaft, available in any length, makes it possible to put the hand-set knob in the most convenient spots.



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MICROCHEMICAL LABORATORY

(Continued from page 151)

performance of a determination. The benches have stainless steel tops, which help maintain the neat appearance of the laboratory.

There are eight chemical balances in the laboratory; two of them are Ainsworth keyboard-operated microbalances, one is an Ainsworth non-keyboard operated, four are Becker semi-microbalances and one is a Becker microbalance. The Ainsworth balance is equipped with an optical lever reading device: by this arrangement a line of light is cast on a scale on the floor of the balance and thus allows considerable ease in the use of the balance; furthermore, this optical lever permits readings as low as a fraction of a microgram and eliminates the danger of errors due to parallax. Readings are made directly to 0.001 mg. on the optical lever scale without estimation or interpolation. The microbalances require a considerable amount of protection from vibrations. Solid tables with Alberene stone tops supported by pipe legs fixed to the floor and braced to the wall by brackets eliminate the risk of disturbance of the balance by the operator. Rubber balls inserted in depressions in the balance case support a balance base which consists of five layers: a plate of glass, a pad of felt, two sheets of lead and a sponge rubber sheet; these precautions obviate the risk of any jars which may be produced by vibrations in the building from the operation of motors and engines, or other causes. The balance cases have special sliding panel doors which have been found to be a distinct advantage over the conventional window type. The new type does away with channels and pulleys which do not work too well on the up-and-down window type of balance case. These sliding panel doors operate on the side just as a glass book case is opened.

Whereas most laboratories still use gas burners to carry out their reactions, the M. I. T. laboratory has undergone complete electrification; all the heating equipment and microcombustion furnaces use electrical power. The microcombustion furnace used in the laboratory is of a custom-made model designed by the director of the laboratory so that the heating elements can readily be replaced on the spot by a simple process. This is a distinct advantage over the alternative of sending out the furnace every time repairs are needed.

The Carbon and Hydrogen Train Apparatuses have special control panels consisting of an indicating control pyrometer, a Variac gauge, and colored signal lights. The Variac gauge controls the load, and is set so that the furnace will not overheat in the event that the pyrometers do not function properly. The signal bulbs indicate by their different colors whether the furnace is heating up, is up to heat, or is overheating.

An electric drying oven, with a temperature control device, is used for the drying of special glassware and halogen precipitates. An electric microcentrifuge produces relatively high centrifugal force and a rapid sedimentation rate. A special glass blowing table in the hood room is available for the construction of apparatuses and for the opening and sealing of Carius Bomb tubes. Another unusual piece of equipment in the laboratory is the specially designed and custom-built immersion heater for the steam generator of the micro-Kjeldahl distilling apparatus.

All the above features combine to make the M. I. T. microanalytical laboratory one of the most modern and efficient in the East. A good microanalytical laboratory is an almost indispensable tool to modern organic research.

"Intellectual improvement arises from leisure"—SAMUEL JOHNSON

Why housekeeping gets "lighter" all the time

"... Woman's work is never done."

True enough. But today's homemaker—aided by her modern refrigerator, range, water heater, vacuum cleaner and other appliances finds more time for family and for leisure.

And what helps these "automatic servants" operate so dependably? *Better materials* for one thing.

Materials on the inside—the unseen working parts of household standbys. Such as alloy steels, new plastics, carbon brushes in motors... lighter, more compact materials that make appliances stand up longer and handle with ease.

Materials, too, that you can see... as those stainless steel surfaces so easy to clean. Or the chemicals in more enduring waxes and polishes, varnishes and plastic finishes.

Yes, today's housewife enjoys new leisure, new freedom from drudgery... thanks to better materials.

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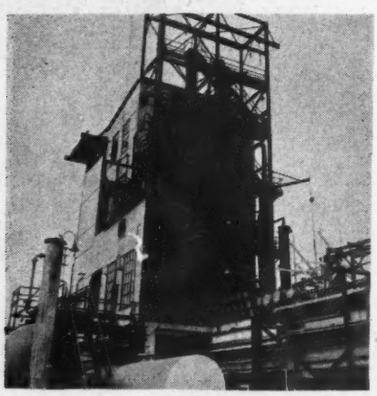
NEW NON-STOP PROCESS PRODUCES G-E PHENOL

If you were to visit the Chemical Department of the General Electric Company at Pittsfield, Mass., you could watch something new in the production of phenol. It's a continuous operation process developed by G-E chemists and engineers. With the completion of this plant, General Electric becomes the only company in the United States to start with the production of chemicals . . . convert them into resin . . . then molding powder or varnish . . . and finally fabricate them into a long list of finished molded or laminated products.

Phenolic compounds are among the most useful molding powders. Since phenol is so important in the fast-growing plastics industry, its processing should be of interest to every young chemist and student of chemistry.

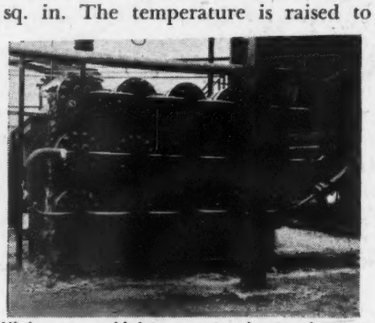
How is phenol made? The basic ingredients used at Pittsfield are benzol, chlorine, and caustic soda.



Distillation building with fractionating towers.

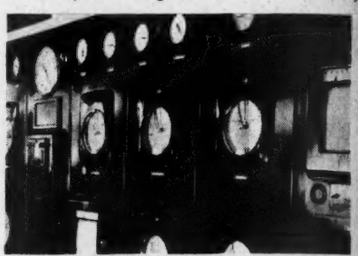
Caustic effluent from electrolytic cells is evaporated to 20 per cent and the salt crystals separated. Caustic is diluted to 10 per cent for hydrolyzing the monochlorbenzol. Chlorine leaving the cells at 180 F. is cooled to 55. The gas is compressed to 20 lb. and goes to the chlorinator. Here it meets with benzol and monochlorbenzol is formed. Gases leave from the top of the chlorinator. The hydrochloric acid is recovered to be used later in neutralizing sodium phenolate to release phenol. The liquid leaving the chlorinator is composed of unreacted benzol, monochlorbenzol, and dichlorbenzols. It is neutralized and the components are separated.

The monochlorbenzol, caustic, and diphenyl ether are then mixed and the mixture is compressed to 4,000 lb. per sq. in. The temperature is raised to



High pressure, high temperature heat exchanger.

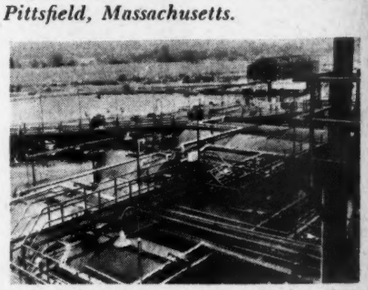
500 F. The feed next enters the radiant section of the tubular reactor and is brought up to reaction temperature. In the convection section the mixture is held at high temperature until the reaction is complete. Substantially all monochlor is reacted to sodium phenolate, diphenyl ether, or high boiling residues. The mixture is cooled and the pressure reduced. In a decanter the diphenyl ether is separated. Phenolate is neutralized with hydrochloric acid forming a brine layer and a phenol-water layer. The phenol is recovered by



Control panel for hydrolysis and distillation.

distillation and sent to storage in tank cars, ready to be shipped to plants requiring this vital compound.

This ingenious and efficient process is another example of what G-E chemists and engineers do to aid in the development of a great many industries and industrial projects. Today the demands of the users of chemical products are extremely varied. General Electric, through its chemists and chemical engineers of today—and tomorrow—will continue to meet those demands. *Chemical Department, General Electric Company, Pittsfield, Massachusetts.*



Tanks storing phenol and intermediate products.

A message to students of chemistry and chemical engineering from

DR. CHARLES E. REED

Manager, Chemical Engineering Division
General Electric Chemical Department

The future of the plastics industry presents a challenge to every student of chemistry and chemical engineering. Here at General Electric—where plastics were pioneered and many other chemical and metallurgical processes and products developed—you may find exactly the facilities and environment you are seeking to carry on your work after graduation.

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